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JOHN ALFRED BRASHEAR, 1840-1920.

By FRANK SCHLESINGER.

John Alfred Brashear, optician, educator, philanthropist, was born on November 24, 1840, in the town of Brownsville, Pennsylvania, about thirty miles south of Pittsburgh. Then little more than a village, this town was the birth place of two other men who attained national and international fame: James G. Blaine, born in 1830, United States Senator, Secretary of State, and Republican nominee for the presidency in 1884; and Philander C. Knox, born in 1853, likewise United States Senator and Secretary of State.

The Brashears had lived in western Pennsylvania for nearly one hundred years when John was born. It is probable that they had come from Maryland. The family was of French Huguenot extraction, and the name is probably derived from *brasseur,* the French for brewer. There was nothing very remarkable in John's immediate ancestry. His father, like himself, had been a mechanic. His father's father was a physician. His mother's father, Nathaniel Smith, was a watch maker, and it was from him that John learned to be an accurate mechanic and from him that he acquired that love for astronomy which was to prove his ruling passion.

John attended the public schools in Brownsville until he was about thirteen years of age. He was willing and eager enough to go on with his schooling, but the family finances were such that it became necessary for him to earn his own living. Accordingly he came up to Pittsburgh and learned the pattern-maker's trade. After a while he secured employment at Mr. Zug's steel mill, on the South Side of the city, where he remained for nearly twenty years, rapidly developing into an expert mechanic and rapidly advancing in responsibility and remuneration. Toward the end of his mill days he was in charge of the rolling mill, which it was his duty to keep in running order. If, as was sometimes bound to happen, the mill got out of order, it became his business to get it going again with the shortest possible delay; for the whole organization had to stop operating until the rolling mill could take care of the steel as it came through. At such times he was wont to stick to his job without stopping for food or sleep until all was right. He has told the writer that he has sometimes labored under these circumstances for forty-eight hours at a stretch.

Only once in those early days did the young mechanic think of changing his occupation. He had developed facility in public speaking, which he exercised in several ways: in giving informal talks to his fellow-workmen at the mill, in the political forum, and finally in the pulpit. He was a member of the Methodist Church and on two or three occasions he had taken a small part in conducting the services. Without stopping his work at the mill (he was forever doing something out of hours), he took the necessary steps for ordination as minister in that church. But he filled the pulpit only once. In telling of the incident afterwards, he was fully alive to its humorous side, but it was also evident that it was a matter of very keen disappointment to him at the time, and that he had not altogether lost this feeling of disappointment in all the years that followed. It seems that the minister of the church expected to be away one Sunday morning and asked Brashear to take his place, which he very eagerly consented to do. But circumstances changed the minister's plans, so that he was one of the congregation that heard Brashear's only sermon. After the service he went up to the young candidate and putting a kindly hand upon his shoulder, he said to him: "John, I think it would be a great pity to spoil a good mechanic for the sake of making an indifferent preacher." Brashear went home with a sore heart, and according to his own account, he spent most of the night in tears. But he took his friend's advice and gave up all thought of the pulpit as a career. Perhaps it will throw a little light upon the incident if it is mentioned that he had chosen the first chapter of Genesis for his text. I have often wondered if his friend did not have greater foresight than Brashear gave him credit for, and whether, when he discouraged Brashear from the pulpit, there was not in his mind's eye something vastly beyond the "good mechanic" that came from his lips.

In the fall of 1862 Brashear married Phoebe Stewart. He was not quite twenty-two years old at the time and she not quite twenty. They built with their own hands a little home on the South Side, near the mill, and there they lived for nearly a quarter of a century. This union was a particularly happy one. They remained devoted to each other through the half century that they had together; they were inseparable in thought, habit, and action. Brashear's success, as he himself always insisted, was due in great part to her qualities of heart and mind. They were both passionately fond of children and made much of them whenever and wherever they came upon them, but no children of their own came to bless their home. Later on they adopted a son and a daughter: Harry, who died while still in his teens, and Effie (afterwards Mrs. James McDowell), who survives them both. It is to her, her children, and her grand-children that the Brashears owed their chief happiness in their old age.

Early in his mill days Brashear acquired a small and in-expensive refracting telescope. This he mounted upon an ordinary wooden tri-

pod and he used to take it out on the little lawn in front of his house on fine evenings. Many a casual passer-by, as well as his friends, got a first glimpse of the sky through this modest glass. He soon began to long for something better, but having no funds, the only way to get this was to make his own telescope. In the little shop at the back of the house he built a grinding machine, and with his wife's help, set out to make a twelve-inch reflector. The story of this glass has often been told; how it met with an accident and was ruined when nearly completed; how his wife lifted him out of his despair by quietly making preparations for a new attempt; and how this time the great venture was brought to a successful completion. Now he began to make reflectors for others, and then, timidly at first but with increasing confidence, he undertook to make and sell small refractors.

All this was done out of hours and after long and fatiguing duties in the mill. It is not surprising that his health broke down and that he was ordered by his physician to give up the telescopes or to give up his work at the mill. Had such an alternative been presented to him a few years earlier, he would have had no real choice but should have been compelled to give up his optical work. In the mean time, however, it had been his great good fortune to attract the interest and sympathy of the one man in the community who could give him the help that he needed to go on with his real work.

It is a pity that no adequate biography of William Thaw (1818-1889) has yet been written. This man amassed a great fortune comparatively early in life and was probably the wealthiest man of his day in western Pennsylvania. The last twenty years or so of his life he devoted more to science and art than to his business affairs. In those years he invested not a little of his time and money in men. The writer is personally acquainted with the circumstances concerning three such investments and in each case the returns (to Thaw in solid satisfaction and to the scientific world in important research) were very great indeed. Thaw's attention was attracted to Brashear through the latter's popular articles on astronomy and similar topics that appeared from time to time in the Pittsburgh newspapers. This interest was fortified through the accounts that he got from his friend Langley concerning the excellence of Brashear's optical apparatus. When, therefore, Brashear found himself at the parting of the ways, Thaw settled the question for him by offering to advance capital sufficient to erect the shop and residence on Perrysville Avenue (now so well known to astronomers and physicists throughout the world) under the shadow of the old Allegheny Observatory. At the same time he offered to back Brashear in a remarkable way; namely, to reimburse him for any financial loss that he might sustain in the effort to let nothing leave his shop that was not as perfect as he could make it. This offer he actually carried out for some years, until the business had well established itself. Soon after the shop was organized, James McDowell, a young

man who had served his apprenticeship in the glass mills of Pittsburgh, joined the company and soon developed unusual skill in polishing optical surfaces. Both Brashear and McDowell recognized how desirable it was that they should associate with their establishment a man who had the necessary theoretical training in optics. Such a one they found in Professor Charles S. Hastings, of Yale University. The coöperation of these three men proved to be a very happy one, and among them they are responsible for much of the astronomical apparatus in use in this country and some abroad. Almost all the spectroscopic instruments in this country that involved new requirements or new design, have been manufactured by the Brashears. In addition some of the largest reflecting and refracting telescopes are the work of their hands, including the thirty-inch reflector at Allegheny, the thirty-six inch reflector at Santiago, the thirty-seven inch reflector at Ann Arbor, and finally the seventy-two inch reflector at Victoria. In recent years they have made the eighteen-inch refractor at Philadelphia, the twenty-inch refractor at Oakland, the twenty-four inch refractor at Swarthmore, and finally the thirty-inch refractor at Allegheny. The writer has had opportunity for examining almost all these glasses while they were in the making, and he is especially well acquainted with the thirty-inch refractor at Allegheny. He can testify that some at least of them are well-nigh as perfect as it is possible to make them. Probably the Allegheny refractor and the Victoria reflector have never been surpassed as master-pieces of the optician's art. Those who seek to find an explanation for the remarkable activity in observational work in this country that this generation of astronomers has witnessed, will undoubtedly conclude that three commercial organizations have played a very large part in this development: the Clarks in Cambridge and the Brashears in Pittsburgh, so far as optical matters are concerned, together with the Warner and Swasey Company of Cleveland on the mechanical side.

In 1893 Brashear was appointed a trustee of the University of Pittsburgh and next year became chairman of the observatory committee, a position he filled until his death. When Keeler came to Pittsburgh as Director of the Observatory in 1892, he at once urged its removal to a better site and the purchase of a thirty-inch telescope. Brashear took up this suggestion with great enthusiasm and in a few years he had collected for this purpose $300,000 from friends of the institution in Pittsburgh. These contributions attest the great interest with which the observatory is regarded in the community, but beyond that they show the respect and affection in which Brashear was held by his neighbors, and the new observatory may well be regarded as his monument.

In 1902 he was called upon to act as chancellor of the University of Pittsburgh. Much against his own inclinations he accepted this call, but refused to consider remaining permanently. Two years later, upon

the appointment of the present chancellor, Dr. McCormick, he retired from the University and once more turned to the optical work in his shop. But he was not permitted to resume this work. For in the meantime he had won a very large place in the affairs of the community, and no civic plan of importance was broached without his council and help. I have never seen elsewhere or at any other time the parallel of Brashear's part in the life of Pittsburgh during the past fifteen years. He enjoyed the confidence of men of every stamp. He was the clearing house for all kinds of projects; charitable, educational, scientific, literary, and musical. No one better than he deserves to be called a philanthropist, for during all these years he labored unceasingly in matters of public welfare and did not allow himself to look after his own affairs as he otherwise would surely have wished to do.

Perhaps the most striking single mark of confidence that was bestowed upon him was in connection with the establishment of the Frick Educational Fund. Mr. Frick made over to him $250,000 and asked him to serve as the chairman of a committee, the other members to be chosen by Brashear himself, for the purpose of administering the income of this fund for the benefit of the school teachers in Allegheny County. No stipulation of any kind was made as to how this fund was to be expended. After due consideration the committee decided to offer deserving teachers summer scholarships in educational institutions, in most cases paying not only tuition fees but travelling expenses as well; and sometimes even living expenses. Mr. Frick was well pleased with the work of this committee and soon doubled his original gift. Finally in his will he left ten shares of his residual estate to the Fund, so that now more than $4,000,000 will be available for the same or similar uses.

Since the recovery from his break down in the late seventies, Brashear had enjoyed uniformly good health for many years. He was small of stature and light in weight, having that wiry build that is best adapted to hard work and seems conducive to long life. But in 1910 he suffered a blow so severe that friends feared for a time he might not recover. Mrs. Brashear had been an invalid since 1901, having broken her ankle in a fall down a long flight of stairs in her home. The broken bones were badly set and as a consequence she first walked only with difficulty and then hardly at all. This enforced inaction aggravated an organic disorder to which she finally succumbed in September 1910, after years of intense but very patient suffering. Brashear had known what the end would be, and knew what a release from pain death would bring to his companion, and yet when the blow actually fell, he was ill prepared for it. It was only through the help of kind friends that he finally managed to resume his interest in life and regain his enthusiasm for his former occupations. But several times since then I have seen him break down, both in the privacy of his home and in public, when he was reminded too strongly of the loss he had suffered.

It was especially in the years that followed that many honors came to him; among them, doctorates from Pittsburgh, Princeton, Wooster, Washington and Jefferson, and Stevens; honorary membership in almost every alumni association that has a Pittsburgh chapter; honorary membership in the Duquesne Club of Pittsburgh and in the Pittsburgh Chamber of Commerce; president of the Engineers Society of Western Pennsylvania, of the Pittsburgh Academy of Arts and Sciences, and of the American Society of Mechanical Engineers. He was a member of the American Philosophical Society, the American Astronomical Society, the American Association for the Advancement of Science, the Royal Astronomical Society, etc. When in 1915 the governors of various states were asked to delegate their most eminent citizens to the Panama-Pacific Exposition in San Francisco, the governor of Pennsylvania promptly named Brashear. In the same year on the occasion of his seventy-fifth birthday, an unparalleled demonstration of the esteem of his fellow-townsmen and of his fellow-countrymen was tendered to him. The largest hall sufficed to hold only a fraction of those who were eager to be present at the dinner on this occasion. Hundreds of telegrams and letters of congratulation were sent from all parts of the country. The central feature of the dinner was a pageant representing episodes in the life of the Brashears; and a beautiful tribute of flowers was placed lovingly in his hands by the members of the Phoebe Brashear Club, an organization of those teachers who had received the benefits of the Frick Fund, and who had established this club in honor of Mrs. Brashear. At the same dinner it was announced that a fund of $50,000 had been donated by various friends, the interest of which was to go to Brashear during his life time as a partial return for what the people of Pittsburgh owed him through his popular lectures; and after his death this fund is to be used in securing the services of others to continue similar work.

On the night of his 76th birthday, Brashear left Pittsburgh for a long journey with a party of friends, among them Mr. Swasey of Cleveland. They visited observatories in the western part of the country and then sailed for a tour in the Orient. When Brashear came back to Pittsburgh in the spring of 1917, he plainly showed ill effects from the long trip; indeed, he never quite recovered from these effects. It was extremely difficult and sometimes impossible to get him to realize that he was no longer a young man, otherwise he might have lived considerably longer. In November, 1919, he caught a bad cold in making a trip to Cleveland. During all the long winter that followed, he left his house on only two occasions. One of these was for the purpose of attending Mr. Frick's funeral, and the other to take part in a testimonial dinner to the writer on his departure from Pittsburgh to take up duties at Yale. These last months were not happy ones for him. In all his long life he had never before been confined to his room, and he felt the restraint very keenly. In the spring it was evident to his friends

that the end was near, and rest finally came to him on the evening of April 7.

When the memorial telescope to Keeler at the Allegheny Observatory had been completed in 1906, Keeler's ashes were removed from California and placed in the beautiful crypt at the base of this telescope. Here Mrs. Brashear's ashes have rested in an adjoining niche since 1910, and here in the same urn with hers, Brashear's ashes have now been placed. The inscription engraved upon their tablet was chosen by Brashear from an anonymous poem called "The Astronomer." It is perhaps the most impressive and appropriate epitaph that could be written for these two souls: "We have loved the stars too fondly to be fearful of the night."

Yale Observatory, June, 1920.

SOUTH OF THE EQUATOR.

By S. C. HUNTER.

Ocean travel in these post bellum days is not what it used to be. Steamers are scarce and besides being undermanned they are operated with a decided show of economy. The spirit of unrest, which prevails everywhere ashore, has also attacked the toilers on the sea, and the result is a deplorable weakening of morale that seems only to add a new and unaccustomed peril to those so often imposed by Father Neptune.

Nevertheless this does not appreciably affect the volume of bookings. The call of the unknown is still heeded by thousands whose doubts and misgivings are promptly minimized by the spirit of adventure. So when we steamed out of New York in early January for the West Coast of South America the cabin list was filled to overflowing and deck space was at a premium. The weather, cold and forbidding, was far from suggesting that within a few hours trunks would be searched for summer clothing. But very soon our winter troubles were a thing of the past, and under the sweet influence of the Gulf Stream we basked in summer sunshine and at night the star-domed skies revived again the fascinating charm that will forever thrill the true observer who makes a trip to sea.

There are many coigns of vantage alluring to the naked eye stargazer, but it is difficult to imagine a better one than the boat deck of an ocean liner, as she slips along in the still and shrouded hours.

Why is it that the stars seem so abnormally bright at sea? Is it because the atmosphere is cleansed of impurities, or does the high degree of moisture at sea level act as a magnifying glass? Whatever

the cause the fact remains that nowhere do the stars shine more gloriously, and the actual degree of unaided illumination they afford appears here to become a real measurable quantity.

We were specially favored by an uninterrupted sequence of perfectly clear nights, as we steamed due south, and it soon became a matter of absorbing interest to note the displacement of the familiar constellations, and the appearance of new ones in the Southern Hemisphere.

Orion and Canis Major, both being well up, and at the same time a dominating feature of both hemispheres, offered favorable measuring rods, and as the familiar stars of these figures each night assumed a higher position, gradually the unaccustomed luminaries in Puppis and Columba stretched the field further and further southward until the giant Canopus finally blinked his welcome, just above the southeastern horizon, soon followed by Achernar in the southwest.

A few evenings later the Great Magellanic Cloud put in its first appearance, whose very name carried with it an assurance we were finally viewing a new and strange field. This Cloud lies about midway between Canopus and Achernar, but to the southward. It is a very modest object, offering no special feature, except its strong resemblance to the Milky Way, while being entirely isolated from it. At first sight it is easily mistaken for a small cloud about 4° across its longest diameter, that has just casually floated into view. To account for its presence will doubtless always prove a challenge to the thoughtful astronomer.

After this we eagerly sought for a glimpse of that much lauded asterism of the southern skies, the far famed Southern Cross. We were not immediately rewarded however, as it was rising late. In fact so late that it could not be found until we were across the equator, and even then it was at first only dimly discernible in the horizon mists. But as we continued our southward journey, it rose higher and higher in the Milky Way, and soon we were able to study at leisure this most popular of all objects in the southern hemisphere.

To say that it was disappointing will not be surprising. Nearly everyone seeing it for the first time seems to agree about this. The impression is unavoidable that its chief claim to fame must rest in the tradition which clusters about it in song and story.

A combination of stars to be really effective should be either uniformly bright or close together. The stars in the Cross are not close together, and there is only one bright one; this marks the foot and not the top of the Cross as in Cygnus. Even this bright star, although rated as first magnitude, is composed of two second magnitude stars nearly 5″ apart.

The other three stars forming the kite shape are two of second and one of third magnitude. In the early months of the year the Cross is seen lying on its side, with the foot pointing approximately towards the south pole of the heavens.

It must also be admitted that serious loss is suffered from a spectac-

ular standpoint by its being positioned on a remarkable patch of background in the Milky Way, which in this region outshines everything else. The most satisfactory way to really grasp the true value of this asterism is to view it as a part of the closely following constellation of the Centaur. Then we have a group of six prominent stars, which include the wonderful α and β Centauri, forming indeed a really striking combination.

α and β Centauri are by far the most brilliant pair found anywhere in the heavens. They follow line ahead like Castor and Pollux, only they are slightly farther apart and of much greater brilliancy.

It will be recalled that α Centauri is the third brightest star (Canopus being the second) and besides being also the nearest star, it claims further the distinction of being the finest binary. Its components consist of two yellow stars of first and second magnitude, with a period of 81 years. Measurements have also demonstrated that at intervals during the past 65 years these components have varied in distance from 7".6 to 21".6. It is difficult to adequately describe the golden brilliancy shot out from this interesting couplet, affording as it does such a sharp contrast to the white rays of the high-riding Sirius and Canopus.

In this same region the famous Coal Sack casts its shadow on the Milky Way. It lies immediately below the Cross and looks like a gaping hole opened in the surrounding filmy brightness. While its name is well applied it should not be imagined as devoid of stars. The unaided eye is sufficient to discern points of light and a good telescope shows a well defined scattered cluster right in the midst of it, supplemented by many separate twinkling specks.

Perhaps the general impression of topsy turvydom is the most striking sensation experienced by the northern observer who visits the Southern Hemisphere for the first time. It is very difficult to get accustomed to the violent displacement of familiar objects in the sky. Orion standing upside down and directly overhead is one of the apparent abnormities. Then the unusual course of the Sun as he sweeps in his diurnal circle northward, instead of southward. It also gives one a start to observe the young moon in the northwest, with the horns pointing apparently northeast.

It is all very well to tell about these things and to try and explain them, but there is nothing quite equal to the shock of making their acquaintance for the first time by actual observation.

To complete the new experiences in Southern latitudes it was quite essential to find some way to get a glimpse through a telescope. At LaPlata in the Argentine there is a fine astronomical plant. This town is located about 35 miles southeast from Buenos Aires, and is the seat of government for Buenos Aires. It is prettily laid out with plazas and a park, and contains the various administration buildings. Thirty years ago the government then in power established an observatory, fitting it out with several telescopes and a fine transit instru-

ment. In the main dome there is a 17″ refractor of French manufacture. Upon arriving at this observatory I inquired for someone who could speak English. It was a lucky move, for in a few minutes I was exchanging greetings with Mr. Bernhard Dawson, a fellow variable star observer. Mr. Dawson is making very good use of the fine instrument under his control and is busily engaged on binaries, recording systematic measurements which will form a valuable and much needed contribution to this branch of knowledge when completed. Meeting some one from home with a common interest was such an unusual circumstance for him that he quickly arranged for my return at the first favorable opportunity for an evening with the stars. A few evenings later I was in LaPlata again; the air having been cleared by thunderstorms made a fine atmosphere for observing. Arriving at the observatory we lost no time and were presently swinging the dome around for a peep at anything that promised interest.

Beginning with a look at Jupiter we swept into the Milky Way and out again to special stars and clusters. It seems strange indeed to realize that here was a vast section of the heavens filled with marvelous objects, which, gazing upon for the first time, I should probably never see again. Among the interesting things we observed was that interesting little Nova, η Argus, now a brilliant red star of 7.5 magnitude to which it has shrunk from zero, and as if to enhance its waning brilliancy it appears entirely enmeshed in a delicately spun mass of nebulous haze. And then we looked at the wonderful κ Crucis, otherwise known as the "Jewel Casket." Words seem quite inadequate to describe the startling telescopic cluster here disclosed as it is always difficult to express color verbally, especially when it sparkles with the peerless brilliancy of a dewdrop in the morning sun. Here was a handful of bright liquid points of colored fire scattered upon a dark background, looking for all the world as if they had been just carelessly dropped there. The chief feature is a pendant of three stars in close alignment, as if β Cygni contained a third star, bright red, between the golden and blue one. The other surrounding stars vary in degrees of red, yellow and white. There is of course nothing like this anywhere else in the heavens and it can never be forgotten by anyone fortunate enough to see it.

It was very surprising to learn that our own familiar Mizar has a striking rival in α Crucis. This star, as already stated, is the only bright star in the Cross and marks its foot. Besides its chief components there is a fifth magnitude star 90″ away which completes the Mizar formation and affords a magnificent telescopic object, even brighter and more compelling than the northern counterpart.

Then we looked at the grand globular cluster designated as 47 Toucani. It is visible to the naked eye as a hazy 4½ magnitude star. In the 17″ refractor it was indeed, as Sir J. Herschel has said, "a superb object." It is said to contain about 1500 stars of the 12th to 14th mag-

nitude. It is larger, more brilliant and altogether superior to its northern cousin, Messier 13.

Following this the cluster 265 Carinæ was a most interesting telescopic object but not in such close formation as 47 Toucani. But the most amazing thing in observing 47 Toucani and Omega Centauri was to remember that, while each was visible to the naked eye, Dr. Shapley's measurements estimate them as the *nearest* of the globular clusters, although each one is at the inconceivable distance of 22000 light years away and each one gives out a total light of a million times the light of the Sun!

The next surprise was to learn that the favorite Orion nebula has a real rival. It can scarcely be classified as in another hemisphere, however, because the entire constellation of Orion culminates in the zenith when viewed from the middle section of the Southern hemisphere, and thus it becomes a dominating feature of both hemispheres. This affords the observer in the south an opportunity to make a direct and immediate comparison with the nebula known as 30 Doradus. Both objects are really very much alike. Doubtless their structural features are precisely the same, and they should be classed together as the most interesting of the diffused nebulæ. Doradus also contains what is considered the reddest variable in the Southern field, namely R Doradus. It was very beautiful, about seventh magnitude, but no fairer to look upon than several Northern variables of similar color, such for instance as χ Cygni at maximum.

Finally my interesting evening came to an end. The telescope was required for regular work, and it was with much regret that I was obliged to bid farewell to these new and remarkable celestial friends, with whom the pity was, my acquaintance should be so brief.

Just as travel is vastly more educative than descriptions contained in books, so first hand observations of the stars will never be forgotten. The satisfaction of having actually seen the region around the Southern Cross, besides remaining always a pleasant memory, will constantly stimulate a desire for a greater comprehension of the entire subject of astronomy.

One thing is certain and that is until one visits south of the equator it is quite impossible to realize the extent to which the northern constellations are there visible. This makes a comparison between the relative brilliancy of the two hemispheres largely a question of deciding where the line of separation shall be drawn. If everything north of the celestial equator is eliminated, then it must be admitted that the southern skies are nowhere near so rich in striking combinations. On the other hand if the entire visible skies are taken from a point as far south as New York is north of the terrestrial equator, then the superior brilliancy of the northern skies is practically confined to the superb galaxy of circumpolar constellations, which clearly outclass anything around the south pole, except the Cross and Centaur groups. It is true

that the Milky Way is nowhere more brilliant than at the extreme southern end. It is certainly a wonderful sight.

But after all it is the glory of the entire visible heavens which appeals to the imagination of the thoughtful observer, and the wonders disclosed by telescope and camera are enough in all conscience, whether to the north or south, for endless speculation and theory to explain anew the processes of creation.

TO THE AMATEUR OBSERVER.

By MISS ELIZABETH EMORY.

So much has been said of the wonders of the heavens as seen through our larger instruments, that the enthusiast, fresh in his recollection of some vivid and illumining experience, is apt to forget the difficulties of the amateur who on his first glimpse through a telescope, is too often apt to turn away with a vague sense of disappointment.

He, the amateur, does not realize that the faculty for telescopic perception grows only with patient practice at the glass. Like other faculties, it needs development, and at the telescope as with the microscope, the eye must be trained before it is fully prepared to roam the strange landscapes which these instruments reveal. In addition, few laymen understand the rarity of that second vital aid to astronomic sight—a still, transparent sky.

On this subject the late Doctor Percival Lowell had much to say in connection with the delicate and geometrcal markings on Mars known as the Canals; and only prolonged experience at the telescope with its alternations of poor seeing and abrupt, startling vision, can bring to the amateur a recognition of these elements as indispensable factors of success.

To the student who patiently and systematically works for them, such moments of definition must come, and with them an understanding which no books could give, of the truths and meanings of astronomy.

Illustrative of the average experience in this direction, the writer well remembers her own first moment of clear seeing after many trials and discouragements.

The telescope that evening was focussed on Saturn, shining just then against a background of the Milky Way. At first glance the image was slightly blurred by the "boiling" of air-waves magnified by the lens, and through an optical illusion common to amateurs, the planet appeared, not as a world seen in the ocean of space beyond, but as an object without perspective, floating in the far end of the glass.

What the mind in its dim way felt, the eye was too limited to follow. Another effort was about to end in discouragement, when a curious change occurred. Quite suddenly from the telescopic field the dimness vanished, and the sky as we ordinarily know it disappeared. Atmospheric vibrations, so often a hindrance to definition, were stilled, and vision, losing all consciousness of the small personality belonging to it, ranged out, not up, through vast stretches of transparent space. So still and clear was that ocean of ether, that in a sense, even distances were palpable. Stars, scattered under ordinary conditions, at apparently equal distances from the earth, now shown as it were from contrasting distances, some more, some less remote. But each was clearly ranged in units of light-years so far from the borders of our solar system,that the mind seemed confronted by intimations of a new order of perception, and intellect itself as we usually understood it, shrank before the strange, new revelation of those spaces.

Comparatively close at hand, but now by earthly standards very far away, Saturn with its satellites like points of silver, stood out with indescribable clearness against the background of the stars. In the purity of the surrounding vista its convexity was plainly visible. And set about it in space, the rings sharply etched, even to the inner film of "crepe" seemed, with the whole, to be permeated by a force which sustained and made one all visible things, from the farthest star glittering in the intense quiet of the ether, to the small and cheerful cricket singing (over his dinner no doubt) on one of the observatory sills.

Then the accustomed tremor shook the telescopic field. Between the eye and that strange glimpse of space the vibrations of the atmosphere had spread their veil again. But for a moment Knowledge had touched with her presence one small spark of the cosmic life, and with that touch, the old familiar aspect of the world, and its ultimate illusion of the commonplace had vanished forever.

AITOFF'S EQUAL-AREA PROJECTION OF THE SPHERE.

By R. L. FARIS.*

A projection of the whole sphere on an equivalent or equal area system devised by Aitoff, has just been issued by the U. S. Coast and Geodetic Survey, size 11 inches by 22 inches, price 15 cents.

The sphere is represented within an ellipse with major axis twice the minor axis. No shoreline has been included since it is intended primarily for the plotting of the stars in astronomical work, its value for

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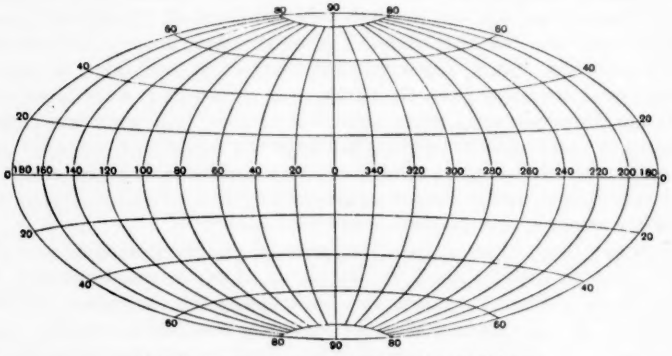
this kind of work being suggested by Professor Benjamin Boss of the Dudley Observatory, Albany, N. Y.

The projection is bounded by an ellipse similar to that which is used in Mollweide's equal area projection but, since the parallels are curved lines, the distortion in the polar regions is less in evidence. The net-



Aitoff's Equal Area Projection of the Sphere.

work of meridians and parallels is obtained by the orthogonal or perpendicular projection of a Lambert meridional equal area hemisphere upon a plane making an angle of 60° to the plane of the original.

The fact that it is an equivalent or equal area projection combined with the fact that the celestial sphere is represented in one continuous map, will show at a glance the relative frequency of stars in the different regions of the expanse of the heavens. As constructed the radius of the sphere to be projected is taken as a decimeter so that the graticule has a very convenient size for general use.

As used for a map of the world, this projection is well adapted to replace the Mercator projection in atlases of physical geography or for statistical purposes and has the advantage over Mollweide's in that its representation of the shape of countries far east and west of the central meridian is not so distorted, because meridians and parallels are not so oblique to one another.

By employing the meridian of Greenwich as a central meridian, the continental masses can be mapped where the projection is at its best and the greater distortion transferred to the Pacific Ocean.

NOTE ON THE TEMPERATURE OF THE EARTH'S INTERIOR.

By WILLIAM O. BEAL.

From the time that modern civilized men admitted that the earth was round like a ball until quite recently it has been generally taught that the central part of the earth was enormously hot, so much so that we were pictured as living on the surface of a solid shell or crust, perhaps fifty miles thick, which rested on a ball of hot fluid rock. The evidence which led to this conclusion was the existence of hot springs, geysers, and volcanoes. The phenomena associated with active volcanoes are very impressive. Occasionally a great mountain splits open and a flood of molten rock flows down its side devastating the whole region. A witness of such a scene might easily fail to realize how insignificant a part of the whole world was really affected, and that almost all of the inhabitants of the earth were blissfully unconscious that anything unusual was happening.

In addition to this evidence the temperature in deep mines and borings has been found to increase with the depth about one degree Fahrenheit for every 100 feet. But really man has only picked into the surface of the earth a tiny way in comparison with the distance to its center, so it is hardly reasonable to assume that the temperature increases with the depth for 25 or 50 miles at the same rate as it does for the first mile.

Imagine the earth enveloped in a perfect insulator. There would be a continuous flow of heat by conduction from the central parts of the earth to its surface, until all parts of the earth had acquired the same temperature. The earth having acquired a thermostatic condition of uniform temperature, imagine its insulator removed. The surface temperature would fall rapidly on account of radiation, and flow of heat would begin from the underlying strata toward the surface. It is evident that in the earlier periods after the removal of the insulator the temperature gradient would be greatest at the surface and would decrease as the depth increased. A little reflection makes the same conclusion regarding the temperature gradient look reasonable, even after a long period of radiation when the temperature at the earth's center was falling; for every concentric layer of the earth acts as a partial insulator. Fourier investigated this matter for small solid spheres such as can be studied in laboratories and found that the temperature gradient decreased toward the center.

The gradual loss of the internal heat of the earth is believed to result in a corresponding shrinking in its diameter, which in turn would generate more heat. This shrinking would most likely occur at much greater depths than are accessible to man, tending to maintain the inte-

rior of the earth at a more uniform temperature, with a more rapid falling off of temperature in the so called earth's "crust".

This conception of the increase in temperature of the earth with the depth is analogous to the increase in the height above sea level of the surface of the water in a stream flowing over a fall or weir as you go up stream from the crest of the fall.

Several independent tests of the condition of the earth's interior agree in indicating that the whole earth behaves as a rigid and highly elastic body. This in itself is sufficient reason for being careful *not* to give out the impression that the temperature of the interior of the earth increases proportionally with the depth.

The inspiration for the above came from discussions that occurred in my classes in descriptive Astronomy. Since it was written, my colleagues, Professors Posey and Swann have called my attention to some of the more extended discussions of this question by Lord Kelvin, and by Chamberlin and Salisbury in Vol. 1 of their Geology. On page 560 of the Geology is a diagram which illustrates the main point of this note.

Minneapolis, Minn.

A HYMN TO THE INFINITE.

Oh! Heaven, boundless space eternal,
And home of infinites supernal.
The setting of a million stars,
No earthly chain thy beauty mars.
Where softly gleams the Milky Way
And lordly Sol holds favoured sway,
Where Luna, Queen of Night, dwells high,
In endless reaches of the sky.

Thy secrets thou dost jealous hold,
And only to those men unfold;
Who zealously do search thy face
With love of Nature's wondrous grace.
Who seek the beautiful and true,
The fresh and great, the ever new.
To them thou dost thy Peace disclose
Like sweet perfume from summer rose.

Oh! grandest sight of mortal man,
Who dost with awe thy wonders scan.
What may not lie in thy dark deeps
What latent force in thee yet sleeps?
Time only will suffice to show,
And then full perfect we shall know
When Part is gone, and Whole is come,
Then we shall know thy glorious sum.

—W. Tait.

THE CONON BRADLEY SNOW FIELDS

By WILLIAM H. PICKERING

The small crater known as Conon is of interest as being situated near the crest of the highest portion of the Apennines. It measures thirteen miles by fifteen in diameter, and is located in longitude 358°, latitude + 22°. Its midday is reached at colongitude 88°, and its sunset at 178°. Bradley may be described as a high promontory extending as a long crooked ridge to the north-east from Conon, and rising to a height of 16,000 feet above the level of the Mare Imbrium. It is bounded by the latter on the east, and on the west by a narrow and very deep valley.

The general lay of the land is illustrated by Figure 1, where *C* indicates the boundary of the floor and the rim of Conon, *E* the edge of a series of high cliffs, *R* the high ridges, *r* those that are less marked, *p* summits and isolated peaks, *h* comparatively low hills, *c* craterlets, *s* certain snow patches, *v* little sloping valleys, and *V* large and very deep ones. The continuous line *f* indicates a fissure, and the dotted line *f* an assumed one, which is believed to lie along the south-western edge of the Mare Imbrium, but which has not hitherto been detected. The are *F* is an elongated, low lying, and conspicuous field of vegetation, which rapidly darkens under the rays of the rising Sun, and in a few days spreads to, and later across, the cleft *f*, and onto the high tableland beyond *E*. The two valleys *v*, *v*, remind one strikingly of smooth glaciated slopes between rough and jagged ridges. The two snow fields *s*, *s*, lie on the other side of the summit ridge, but under a low rising sun, from the point where the western one later divides, an exceedingly delicate dark line, looking like the shadow of a median moraine, following a slightly curved course, descends to the eastern edge of the craterlet *c*, in the western valley. What might be a terminal moraine crosses the valley at this point, but it is not very clear. In the eastern valley, however, what looks very much like a breached terminal moraine extends part way across the lower end. The valleys are each about eight miles in length. Many snow patches and clouds are visible in this region. It is often difficult to distinguish between them, and it is believed that they frequently occur together. When separate, the clouds are identified as less brilliant, more yellow, and more subject to change. They cling to the ridges and higher levels, like fog or mist, and do not float freely in the air as with us. What at first seems strange is that the snow is not of uniform brightness. This is doubtless because the rocks pierce it in various places, and where there is much rock the snow appears less brilliant. All of the snow

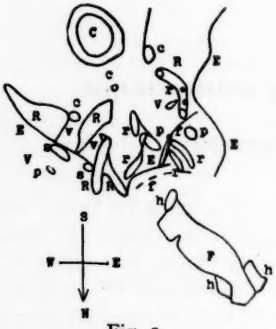


Fig. 1
Elevations and Depressions
Topographical Features

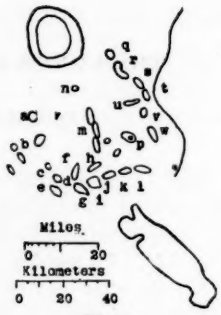


Fig. 2
Snow Fields

Fig. 5
1920, Jan. 28, 8^{d}, **10°3**, 11

Fig. 6
1920, Mar 28, 9^{d}, **19°8**, 12

Fig. 9
1919, Oct. 6, 13^{d}, **64°0**, —

Fig. 10
1920, Feb. 5, 16^{d}, **107°7**, 8

Fig. 3
1919, Oct. 2, 9^{d}, **26°9**, 9, 6

Fig. 4
1920, Feb. 5, 16^{d}, **107°4**, 6

Fig. 7
1920, Jan. 30, 10^{d}, **34°8**, 12

Fig. 8
1919, Sept. 6, 12^{d}, **56°9**, 10

Fig. 11
1920, Feb. 7, 18^{d}, **132°5**, 6

Fig. 12
1920, Feb. 10, 21^{d}, **171°2**, 8, 11

patches exceeding one mile in diameter are shown in Figure 2, and the more interesting ones are lettered. All are not clearly visible at once however, and some of them markedly change their shapes while melting.

The next two figures were drawn with the 3-inch finder, and a half-inch eye-piece, magnification 90, in order to indicate what may be readily seen with a small telescope in the north. Following the date under each figure is given the age of the Moon in days, the colongitude, and the seeing. The eight remaining figures were drawn with the 11-inch refractor and a magnification of 330. The brightness of the snow patches, like photographic negatives, is indicated by their blackness. The very brightest, 9 and 10, on a scale of 10, are a full black. Brightness 8 is indicated by cross lines, brightness 7 by parallel lines, brightness 6 by dots, and fainter regions are left blank, being merely enclosed by a continuous line. The darkness of the soil and vegetation is indicated by figures, the blackest being numbered 2. Unnumbered areas are in general 5. Shadows are indicated by a heavy boundary line, and the letter *S*.

To perceive the advantage of an 11-inch aperture over a 3-inch, in this climate, we may compare Figures 3 and 4 with Figures 6, 7 and 10, drawn at about the same colongitudes. This is not quite fair to the 3-inch, because we could have used a higher power with advantage on it here. This would rarely be possible in the north, and as we wished to indicate what can be seen there, we used the same eye-piece on both telescopes.

We have no enlarged photographs with which to compare Figures 3 and 4, and direct prints are always at a distinct disadvantage. By turning to the Lunar Atlas H. A. **51**, or to the writer's book, "The Moon," we may identify Conon by means of the drawing and photograph of the first quadrant at the end of the volume. Bradley is incorrectly located there, but its crooked ridge, shown in Figure 3, is easily recognized in the Atlas on Plate *7B*, taken at colongitude 43°. The dark patch of vegetation farther north marked *F* in Figure 1, is also readily seen. Turning to Figure 4 we find that the snow patch on Bradley has completely melted at its southern end, and only a faint trace is left at the north, when it approaches a new and brilliant snow patch not shown at all in the earlier sketch, but which first appears faintly in Plate *7C*, 79°, in the Atlas. Another new and even more conspicuous snow area has also deposited a little to the south of the southern end of the field *F*.

Comparing now Plate *7B* with *7D* in the Atlas, the fading of Bradley is clearly shown, as well as the formation of the fresh snow areas to the east of Bradley and near *F*. At this time bright clouds develop all along the north-eastern slope of the Apennines, and the advance easterly of this cloud and snow with increasing colongitude is strikingly shown by a comparison of Plates *7C* and *7D*, colongi-

tudes 79° and 135°. The Alps on the contrary farther to the north, where the range of temperature is less, show but little change. The formation of these cloud areas in the region just to the east of that depicted in the figures is very noticeable in the telescope. In *7D* we see that the last patch of snow on Bradley has melted, only that on the face of the Apennines remaining. This is shown still better in *7E*. This is confirmed by the drawing with the 11-inch, Figure 11, where a little snow in one of the craters remains.

Before describing the remaining figures, which were all made with the 11-inch refractor, the writer proposes to take the radical step of introducing a number of new definitions to describe some of the more delicate lunar markings. This seems suitable in this place as it is proposed in this and subsequent articles to represent various lunar features possessing characteristics which have not hitherto been recorded by other observers. The terms "canal" and "lake" which the writer had previously borrowed from Martian nomenclature, are certainly objectionable there, but are still more so in the case of the Moon. This is because they convey to the public mind, unless carefully instructed, not only a wholly erroneous impression as to their nature and appearance, but even an idea of human construction, since on the Moon they are of such small dimensions that they are quite comparable to the works of man. Moreover, it is certain that we have nothing on the Earth at all resembling them, and for which they could properly be named. It is therefore proposed to select a couple of names which are entirely noncommittal, and which do not imply any particular theory or explanation regarding them. It is not proposed to drop the original names entirely, however, but rather to use them as synonyms, much as we use "road" and "street," "pond" and "lake." The word "field" has been already used in this article, and in one of the earlier ones referring to the dark area near Aristillus.

A Field may be described as a marking which usually darkens as the Sun rises higher and higher upon it, and later fades out again. It may or may not change its size and shape with the progress of the lunar season. The term is analogous to the word "mare" used in connection with the planet Mars.

A Run is a long narrow marking, straight or curved. It is analogous to a Martian canal.

A Plat is a small variable dark spot, smaller than a Field, and analogous to a Martian lake.

A Stripe is a marking descending the inner snowy wall of a crater, and somewhat darker than the wall itself. It is probably simply a region bare or partially bare of snow.

A Source is a minute temporary black point.

A Cloudlet is a minute temporary white spot.

A Streak is a bright line, presumably a crack emitting vapour.

The variable dark areas are believed to be due to lunar vegetation. Why some of them should assume the forms of canals or runs is not known. The white areas are believed to be due to deposited snow, or low lying cloud, or both.

Referring now to the drawings made with the 11-inch, Figures 5 to 12, Conon itself is interesting, because it shows how it is that new peaks are sometimes discovered within craters that have been already carefully drawn by skilled observers at presumably favorable colongitudes, and reported as containing no central detail. Thus Maedler discovered a central peak in Conon. not seen by either Schroeter or Lohrmann ("The Moon," Neison, p. 177). Nevertheless the last named observers were correct, because there is no central peak there. As the sun rises upon the crater, the heavy shadow covering its western inner wall gradually retires, and by 19°.8, Figure 6, the floor is seen to be perfectly clear and smooth. Yet with favorable seeing considerable detail may be discovered upon it. This is shown in Figure 13, in which no attempt is made to indicate the relative brightness of differ-

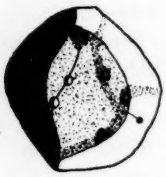


Fig. 13
1920, Mar. 28, 9^d, 19°.8, 12

Fig. 14
1920, Feb. 2, 13^d, 69°.6, 8

ent portions of the crater walls, except the heavy shadow and the two stripes. This figure is therefore drawn as a positive, and what is dark in the drawing is dark on the Moon.

North-west of the centre a minute craterlet can be seen, some 4000 feet in diameter. This is located on a crack passing near the centre and reaching to the southern edge of the floor. One-third way along this crack a still smaller craterlet is found, and at its southern edge a plat or lake. From this a curved run or canal extends north-easterly across the floor, and at its farther edge meets a very narrow run descending the inner face from a minute source half way up its side. Two stripes on the southern and eastern wall connect with the run crossing the floor. This run is continued to the shaded north wall of the crater. The impression is gained that the two stripes, and especially the little source on the north-eastern wall, have a good deal to do with the markings on the floor. This impression is not based on Conon alone, but on a more or less detailed study of a number of simi-

lar markings elsewhere upon the Moon. As the lunation proceeds, at 32°.5, little change is noticed in the runs and plates. The central crack has mostly disappeared, but what strikes us at once, is not only that the northern crater has distinctly increased in size, but that the shadow within it, instead of being on its western side, as in the case of Conon and the other craters, is now on its eastern. In other words it has ceased to be a hollow, and has become a mound!

By 44°.7 this mound has still further increased in size, and now measures some 8000 feet in diameter. Two other smaller ones have also appeared on the floor to the south-west and to the east of it. The inner eastern wall has diminished in brilliancy, and the source and run descending from it have disappeared. By 64°.0 the mound has increased greatly in size, and now joins the crater wall to the center of the floor. Its area is about 30 square miles (See Figure 9, drawn Oct. 6, 1919). This is probably the appearance that it presented to Maedler. By Figure 14, colongitude 69°.6, drawn Feb. 2, the spot appears smaller and more pointed, and a large plat is shown to the south of it. This plat is also indicated in Figure 8 as being very conspicuous, with a luminosity of only 2. Yet on a drawing made April 1, 1920, colongitude 68°.6, the bright area shows but little growth beyond the size of the original crater, and barely reaches one-third way across the floor. The plat was not even recorded, although a special large scale drawing was being made of the crater. Here we have a variation in two different lunations similar to that observed in Eimmart, described in Harvard Bulletin, 544, although on a much smaller scale. As the lunation proceeds, the point of the spot recedes towards the rim and broadens out, and by 132°.5, Figure 11, has entirely disappeared, leaving the central floor perfectly smooth and free of detail. We can hardly doubt that this object is simply a cloud.

When the Sun first strikes the interior of the crater the brightness of the snow on its eastern inner rim is 8, but it soon brightens to 9, and then gradually fades until by 107° it has quite disappeared. The other side then brightens, but never exceeds 8. Bright exterior cloud of luminosity 5 will be noted to the east of the crater in Figures 10 and 11, but has disappeared by Figure 12. It is readily recognized, as it conceals the outer detail, thus apparently changing the shape of the crater. It is a rather unusual phenomenon.

There are a number of craterlets in this vicinity, three forming a nearly straight line just to the north and east of Conon. Two of these, *a* and *q* of Figure 2, have been selected as the primary stations from which position angles should be measured. Their azimuth referred to the Moon's axis is $123°.2 \pm 0°.9$. On the ridge above the former lies the large snow field *b*, which in all the drawings until colongitude 14°, and in most of those until 26°, appears single. At 10° it is sometimes crossed by a dark line, which is hardly more than a

shading, but later, by 20°, becomes more marked, and in Figures 9 and 10 clearly divides the snow in two. In Figure 11 the snow has disappeared. The earliest drawing showing it double was made August 4, 1919, colongitude 14°.4. The latest showing it single was made March 2, 1920, colongitude 64°.1, or after an interval equivalent to four terrestrial days. This was most exceptional, as never before had it been observed as single later than 32°.9. It may for this reason be well to record the notes made on the previous days.

Feb. 28, 27°.8, *b* is undivided. There may be a slight darkening, but it is only suspected. Seeing 6.

Feb. 29, 39°.2, *b* is not divided, but is shaded in the middle lightly. Seeing 10.

March 1, 50°.9, *b* still single!

March 2, 64°.1, the band in the middle is darker and noticeable, but *b* is still in one piece.

March 3, 75°.3, *b* has divided in two. Seeing 10.

When first visible *b* measures five miles in length, and on so large an object the variations in seeing that we have in Jamaica produce practically no effect. Whether March was colder on the Moon than August, or more moist, we cannot say, but we can see that we have here clear evidence either of varying vulcanology, or of "weather," as distinguished from "climate," in the meteorology of our satellite.

Returning to Conon, and following the crooked ridge of Bradley north-easterly, we find it covered by six small snow fields, Figure 2. The first, though visible, is not conspicuous before 14°, since it lies partly in the shadow of a traverse ridge. When the Sun is higher it is seen to be not properly a snow field, but as we have already recorded in Figure 1, a small crater, the snow not extending beyond its rim. The others really are snow fields however, but under a low rising, or perhaps better setting, Sun, when the snow has completely melted, at the summits of the second, fourth, and fifth, we find small but clearly defined craterlets. Under a rising Sun the craterlet in the fourth is often visible, and is then seen to be double. In these cases the snow extends far beyond the craterlet, completely concealing it for much of the time. There is little doubt but that with favorable seeing and a sufficient aperture craterlets would also be detected in the summits of the third and sixth snow fields.

The second field which is at first elliptical or irregular, at about 25° becomes crescent shaped. The third and fourth, at first separate, between 50° and 70° unite (see Figures 8 and 9), thus acting in exactly the reverse manner to spot *b* above mentioned. Sometimes the other spots unite with them. Thus on September 2, colongitude 7°.6, seeing 8, a continuous narrow line of snow was seen stretched from the third to the sixth snow field. On November 4, colongitude 56°.4, seeing 11, the second spot was united to the third and fourth, although

in Figure 8, colongitude 56°.9, they are well separated. Between 70° and 90° a contact, if not a junction between the second and third not infrequently occurs. After that, all these spots save the first fade, and by 135° have generally disappeared.

While faint clouds are seen on the face of the cliff east of Bradley, and on its summit early in the lunation, they do not become conspicuous before 85°. They then suddenly brighten, doubtless due to the deposit of snow, to 6 and 7, sometimes reaching 8 by 107°, and by 9 by the end of the lunation(see Figures 4, 10, 11, and 12). They havebeen recorded of this last brightness as late as 171°. Whether they disappear before sunset at 180° has not yet been determined. If so, the change must be very rapid. If they last beyond sunset, their disappearance before sunrise would be difficult to understand. The region of the suspected cleft, Figure 1, is an interesting one. Its eastern end is clear of shadow by 10°, but not until 19°.8, Figure 6, have we any evidence of what may properly be described as cloud or vapour ascending from it. A bright elliptical shaped object, then appears in the location of *l*, Figure 2. A somewhat similar object shown in Figure 5 is a rocky ledge situated farther to the south. In Figure 7 the bright object has changed its position angle, and been joined by a second, and in Figure 8 by a third. In Figure 9 they have united to form one elongated brilliant object. The appearance of the second and third occurs between colongitudes 32°.9 and 41°.0, or within 16 hours by our time. At this period they are described as sharp at their tops or southern edges, but hazy at their base. At first of brightness 6 they later increase to 9, and later still fade out. beginning at the eastern end, where they started (see Figures 10, 11, and 12, also Plate 9 E of the Lunar Atlas).

With regard to the early shift of position angle of the spot *l*, this is quite conspicuous in the telescope, and it was decided that a few measurements of it could be made to advantage. These are shown in Table 1, and reduced to azimuths. The total shift in the three lunations, it will be noticed, amounts to $+10°.0$, $+5°.4$, and $+7°.4$ respectively. Four measurements taken alternately in opposite directions usually constitute a series.

TABLE I

Azimuth of Spot *l*.

1920	Colong.	Azimuth	Dev.	Shift	Seeing
Jan. 29.....	20°.8	66°.7	±1°.4		8
" 30.....	35.4	76.0	±0.4		11
Feb. 2.....	70.4	76.7	±1.9	+10°.0	7
" 28.....	27.6	69.7	±2.4		7
" 29.....	39.4	75.1	±2.0	+ 5.4	10
Mar. 28.....	20.2	70.4	±1.8		8
" 29.....	32.9	70.5	±1.3		6
" 30.....	45.6	77.8	±2.6	+ 7.4	11

The spots *d* and *e* of Figure 2 occupy a high ridge, and are the most

constant in size, shape, and brightness of any strictly snow areas in this whole region, but between them and the clouds and precipitated snow of the cleft is a region subject to very striking variations between 50° and 100°. The bright masses at first lie nearly north and south, but they later shift their azimuth to an east and west direction, as is well shown in Figures 10 and 11. Later, in Figure 12, *d* and *e* have united to form one area of brightness 8, and the others are seen to have returned to their earlier orientation. It will be found by a comparison with Figure 1 that this region is crossed by a ridge *R*, lying more or less in the same direction as the original bright areas. The areas themselves are constantly varying from night to night, and are never exactly the same in two successive months. They can hardly be

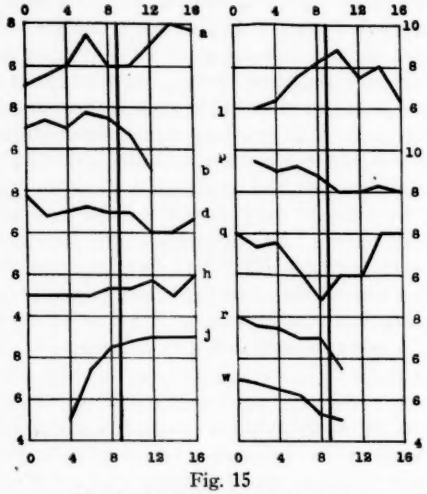


Fig. 15
Varying Brightness of the Spots.

explained otherwise than as due mainly to cloud. Their brightness usually ranges from 5 to 7, but has been recorded, perhaps when reenforced by snow, to be as bright as 8.

The craterlet *p*, Figure 2, first appears out of the shadow at 16°. It is then exceedingly bright, 10, and almost bluish in color. It has evidently been in action during the night. It is very small, about 4000 feet in diameter, and is surrounded by a faint haze of something like a mile in radius, which shifts about as the lunation progresses. It is situated on a wide, apparently otherwise inactive cleft, shown in Figures 1 and 12, and in its immediate vicinity are found a number of elongated bright areas, whose location varies throughout the lunation. They are more or less associated with the ridges, Figure 1, but do not always coincide with them. Their variations are illustrated in Figures 6 to 11.

In Figure 15 is given a set of graphs showing how some of the spots vary in brightness, the abscissas giving the colongitudes and the ordinates the brightness. To obtain the latter quantities, we take the mean of all the results between colongitudes 10° and 30° and plot it under 20°. The mean of all those between 30° and 50° is plotted under 40°, and so on. The number of separate results varies between 1 and 5, averaging 3.0. The heavy vertical lines indicate the colongitude of noon.

There is a surprising variety between the results, indeed it could hardly be greater, but these ten were purposely selected among fifteen, as showing the gratest variety obtainable. The spots *b, r,* and *w* clearly indicate melting in excess of precipitation, indeed they all disappear before sunset. Spot *l* on the other hand shows rapid formation of cloud or snow at noon, with later melting towards sunset. So far as clouds are concerned, that is exactly what occurs in the terrestrial tropics, and is undoubtedly the most frequent sequence upon the Moon. Spot *q* shows what we might most naturally expect to find with a uniform evolution of moisture and precipitation. In the heat of the day the cloud or snow is dissipated, and reforms towards sunset.

It appears therefore that some spots like *b, d, r,* and *w,* which all occupy mountain peaks or ridges, form at night, since they are relatively brilliant at sunrise, while others, such as *j* and *l,* which are believed to originate from a narrow cleft in the soil, appear to require the solar heat to thaw them out, and start them. Spot *h* is a mountain ridge, perhaps occasionally associated with cloud, while the remaining spots, *a, p,* and *q* are craterlets. Craterlet *p* is pretty uniformly active, and not subject to much variation in brightness; *q* is thought to typify the average craterlet, which judged by many of the larger and easily seen craters are brightest when the morning or afternoon sun falls directly on their interior slopes, and are less brilliant at noon, since like Conon itself, their floors are comparatively dark. Craterlet *a* is unusual, but not remarkable, since it is partially concealed at sunrise. It is however evident that its western interior slope is brighter than its eastern, just as the eastern interior slope of Conon is brighter than its western (compare Figures 5, 6, and 7 with Figures 10, 11, and 12).

There is a general impression that volcanic activity is quite extinct upon the Moon. This, like nearly all of the other ideas generally held regarding the surface of our satellite, is wholly erroneous. If the astronomer who once defined the Moon as "the place where nothing ever happens" were ever to find himself upon the floor of Plato, he doubtless would be considerably surprised. There are few if any such large, uniformly, and continuously active volcanic regions upon the surface of our Earth. The activity it is to be understood consists, however, in the quiet emission of steam jets, like those found in our Yellowstone National Park, rather than in Vesuvian explosions. The nearest ap-

proach to the latter perhaps occurred in the summer of 1904, when a rather violent eruption took place from craterlet No. 3 (H.A. **32**, Plate 10, see Harvard Bulletin 156). With sufficiently good seeing it is a very common sight to observe some minute white lunar summit, which at sunrise was perfectly sharp, soon become quite indistinct in the haze, while all other objects around it are sharp and clearly defined. After a few days the indistinctness vanishes, and the peak resumes its clear cut character. An excellent example of this is the central peak of Kant, which has been observed here at some length. Pico and Piton are other striking examples. It must be stated, however, that good seeing, 8 or 9, is a prerequisite for this class of observations.

When the Sun first rises on the region north of Conon several of the snow fields are hazy, such as *b*, and notably *c* and *d*. A particularly interesting feature about these last two, and one that is also unusual, as far as the writer has observed, is that the snow is seen to drift from them in sheets, appearing much as it does in a minor way in one of our blizzards. Whether this really represents a fact, or is merely an appearance, it is impossible to say, but on a small scale it reminds us of the little components of the bright streaks surrounding Tycho, each of which radiates from a small craterlet at its apex. No clear evidence of motion due to wind has ever been seen in the lunar clouds, which apparently merely form and dissolve *in situ*. These seemingly drifting sheets of snow or cloud are therefore of especial interest. They measure about a mile in length by half a mile in breadth, and extend directly away from the terminator, at colongitude 359°.

The only remaining feature of this region that we need now describe is the large field, or area of vegetation indicated in Figure 1 by the letter *F*. It measures some thirty miles in length by ten in breadth, and is surrounded by three conspicuous hills. North, west, and south of it the surrounding regions are somewhat higher, sloping steeply down to its level. To the northeast, however, the mare appears to be at a slightly lower elevation. Its surface at first very dark under the rising sun soon brightens, and at 10°, ranges from 4 to 4.5, but with the approach of summer, or of lunar noon, whichever we choose to call it, it darkens to 2 and 3 (see Figures 8 and 9). With the approach of sunset it again lightens and has reached 4 in Figure 12. Its outlines are by no means constant, and between 20° and 60° its north-western boundary is distinctly serrated, where six little valleys descend into it, and for a brief interval darken conspicuously. Three rills which look something like riverbeds, two of them being forked, are shown in Figures 5 and 6.

The region between it and the cleft *f* of Figure 1 is particularly subject to variations in brightness. It first begins to darken at about 35°, or immediately after the cleft becomes active, but its boundaries are not sharp. By 40° the eastern side begins to sharpen, and by 50° the remainder is fairly sharp, and the darkness 3 to 4. It is connected with

the main field by a canal at the south-eastern corner of the latter, but the breadth of the canal and the size and shape of the region lying between the two fields are subject to great variations at different lunations. In general the progress of this second field, like that of the clouds issuing from the cleft, is towards the west. The third field, that situated on the table land south of and above the cleft, does not become clearly defined, perhaps on account of its elevation, until about 60°. Its duration is brief, and we have no record of it after 107°, when its area was much reduced. The maximum darkness of these three fields is recorded as 2, 3, and 4.

We may close with a brief summary of the more interesting changes and features to be observed in this portion of the Moon's surface, arranged in the order of their colongitudes.

1. 359°. Hazy summits with apparently drifting cloud or snow.
2. 10°. Rills emptying into the large permanent field.
3. 10° to 90°. Union of various snow areas on Bradley.
4. 14° to 64°. Partition of snow area *b*.
5. 16°. First appearance of crater *p*.
6. 19°. Cloud begins to rise from the cleft at *l*.
7. 20° to 60°. North-western edge of the permanent first field serrated.
8. 21° to 45°. Change in azimuth of *l*.
9. 25°. *r* becomes crescent shape.
10. 30° to 60°. Clouds shifting about *p*.
11. 32°. Cloud begins to form on floor of Conon.
12. 33° to 41°. Clouds from the cleft form at *k* and *j*. They are sharp at the top and hazy at the base.
13. 40° to 50°. Second field develops sharp boundaries.
14. 40° to 180°. Shape of region between the first and second field, and shape and size of latter changing.
15. 50° to 100° Shifting clouds west of cleft.
16. 70°. Cloud in Conon reaches its maximum size.
17. 85°. Bright clouds condense east of Bradley.
18. 107°. Clouds form outside and to the east of Conon.
19. 107° to 170°. Clouds from cleft retreating towards the west.
20. 178°. Bright clouds east of Bradley disappear.

Possibly numbers 3, 15, 16, and 17 might be influenced by a lunar eclipse. In order to observe some of these changes excellent seeing and a fairly large aperture are required. On the other hand some of them can certainly be detected with a 3-inch telescope. Perhaps the easiest ones are numbers 5, 6, 12, 14, 17, and 20. It would be a matter of interest to learn how many of the other changes mentioned can be detected by northern observers with either large or small telescopes. For instance a comparison of a 3-inch here, with an 8 or 10-inch in the north would be of interest. Professional astronomers seldom study

the Moon, probably because they can see so little there that is really new, but perhaps some amateur will tell us his own experience. It may interest some observers to see how many of the different snow fields they are able to identify. Having watched and drawn them through a single lunation, they will then enjoy reading in their text books that no changes have ever been detected upon the Moon, and will then perhaps wonder what has become of the evaporated snow and cloud, since the same text books assure them that the Moon does not possess an atmosphere.

Mandeville, Jamaica, B.W.I., April 3, 1920.

TIDAL ACTION.

By F. J. B. CORDEIRO.

In Figure I, *F* is a light frame which supports at one end a round rubber disc, *A*, with two electro magnets, *M,M;* and at the other end, a counterpoise, *B*, which balances the whole apparatus about the pivot, *P*. The rubber disc is on the same axle with a heavy pulley below the frame (not shown) and its circumference is surrounded by a thin, flexible steel band which moves in close proximity to the poles of the magnets. If, by winding a string around the pulley, we give the rubber disc a rapid spin, it comes to rest slowly through the friction of the axle. If we energize the magnets by passing a current through them, the rubber disc becomes distorted into the oval shown by the dotted line and any spin is quickly annulled. The action is the same as if we ap-

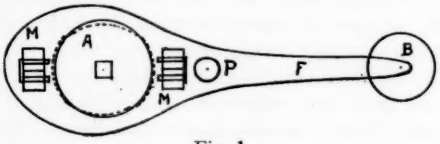


Fig. 1

plied a mechanical brake to the circumference of the disc. That this braking is not due to eddy currents—an example of Lenz's law—we may prove by substituting for the rubber disc an equal wooden disc with the steel band fitted around it as before. We shall now find that when the magnets are energized, the braking effect is inappreciable, proving that the annullment of the rotation is due practically all to the distortion of the disc. The braking couple must have a "point d'appui" or there must be an equal and opposite reactionary couple of inertia. This is shown by the fact that, as the rotation is destroyed, a revolution of the entire system about the pivot, *P*, is set up, and, if there were no friction at the axle and at the pivot, the total amount of momentum

would remain unaltered. Likewise the energy of the system remains unaltered, all kinetic energy which is destroyed reappearing as heat. Our distorted rubber disc becomes hot, just as an automobile tire rotating under a distortion becomes hot, and the lost rotational energy is precisely equal to the heat evolved.

Our model represents exactly the action between the earth and moon. Dispensing with frame, magnets, pivots, etc., let A be the earth, and B the moon. The balance between the centrifugal and attractional forces keeps them at a constant distance as they revolve about their common center of inertia, P, and their distances from this point are inversely as their masses. But tidal forces distort their otherwise spherical figures into ovoids pointing towards each other, and, as we have seen, this necessitates the rotations and revolutions, whatever they originally were, being brought into an identity of periods. When the moon originally consolidated into a single body, it must have had a considerable rotational velocity, but under the tidal action of the earth this velocity must, within a comparatively short time, have been reduced to the revolutional velocity. The destruction of any considerable amount of rotational energy in a short time must have produced an enormous amount of interior heat, and the volcanic surface of the moon bears evidence to this very great heat as well as to its comparatively short duration. Whatever the moon's temperature originally was, it must subsequently have become very hot and with the cessation of tidal action it must as rapidly have cooled.

In the same way the earth's rotation is being reduced and its interior heated by tidal distortion, and eventually the day and month, for both moon and earth, must become the same, or they will always present the same faces to each other. The moment of momentum of the system must always be the same.

Taking the earth's mass as 81 times that of the moon, let r be the distance of the earth's center from the common center of inertia. Neglecting the moon's rotational moment, which is very small compared with that of the earth ,we can write the momental equation,

$$2\phi'/5 + 82\, r^2 \theta' = k$$

where ϕ' is the earth's angular velocity, and θ' is the revolutional angular velocity of the system. Taking for units of length and time, the earth's radius and one of our present days, we have

$$2\phi'/5 + 82\, r^2 \theta' = 13.11 \qquad (1).$$

In these units, the earth's mass is 11288, and the combined mass of the earth and moon is 11426. Hence, by Kepler's third law, we have

$$r^3 \theta'^2 = .02235 \qquad (2),$$

but it must be remembered that this is on the supposition that the earth attracts like a material point.

Taking r as an abscissa, and plotting corresponding values of ϕ' and θ' from equations (1) and (2), we obtain curves, the general shapes of which are indicated in Figure 2. These curves begin with the same value at A, afterwards diverge and become again united at B. The

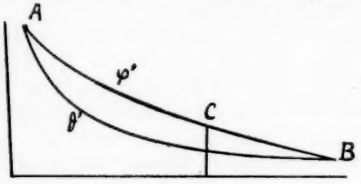


Fig. 2

line C indicates the present state of affairs. Now the point B, where ϕ' and θ' have the same value, corresponds to a distance between the bodies of about 374,000 miles, and the common period is 51 days.

This has been called the *first identity*.

We have considered only the earth and the moon, but since the sun is also slowing the earth's rotation, though to a less degree than the moon, the time of the first identity will be somewhat anticipated. Without entering into the computation, we may say that the time will inevitably come when the earth and moon will perpetually present the same faces to each other, and the common period of the system will then be some forty odd days—say, roughly, forty-five days. But the sun will continue to retard the earth's rotation and any retardation of the earth's rotation will, secondarily, retard the moon's revolution. Hence the sun will retard the earth-moon system as if they were rigidly connected. This means that the two bodies will then fall towards each other.

By the same method, but using slightly different data for the ratio of the masses of earth and moon, Kelvin (*Nat. Phil.* Art 276), gives 48 days as the period of the first identity, while Darwin (Tides) gives 55 days. We are not concerned with an exact determination, but it suffices to say that the earth-moon system, by itself, would, through tidal action, separate to a distance of about 375,000 miles, where the common period would be a little more than 50 days. But tidal action of the sun on the system reduces these figures, so that the maximum distance between the earth and moon will be about 325,000 miles, where the common period will be about 45 days.

From this first identity the earth and moon will approach each other, while the system will recede from the sun. A little consideration will show that the members of our solar system must consecutively fall together until only two bodies are left. But Kelvin does not stop here. Believing the ether to be a viscous medium which destroys motion, he concludes that these last two bodies will fall together, "Into one mass, which, although rotating for a time, must in the end come to rest rela-

tively to the surrounding medium" (l. c. Art. 277). If we admit the viscosity of the ether, the eventual consolidation of the system is inevitable into a single cold mass, with or without tidal action. From various considerations which cannot be entered upon here, my conclusion is that the ether is absolutely frictionless. Hence by tidal action and by tidal action alone, our system will eventually be reduced to two cold bodies.

The mechanism by which tidal action (equalization of rotational and revolutional velocities) is effected, is clearly presented by the model I have given. Any two attracting bodies, solid, liquid or gaseous, are by their differential attractions drawn out into ovoids with their long axes pointing towards each other. Any rotation across the line joining their centres is opposed by the kneading and friction of the particles on each other, as they attempt a rotation, which is essentially circular, in ovals. Any relative rotation is therefore annulled, with the development of heat. The usual explanation, however, is that tidal action depends upon surface fluids, or oceans. In the case of the earth which is covered with a thin skin of water over 3/4 of its surface, the sun and moon cause this water to move relatively to the solid surface, and in so far as some of this motion is transformed into heat and radiated away, there is theoretically a certain amount of energy lost, which is at the expense of the earth's rotation. Practically, any showing of rotation from such a source is insignificant and not to be considered in comparison with the real factor in tidal action, viz., the distortion of the earth's figure.

We shall prove directly that two bodies, which are considerably disproportionate in size, cannot approach each other within a certain critical distance without the lesser body being torn to pieces by tidal action. The moon is destined to come within this critical distance when it will be torn to pieces and form a meteoric ring revolving exactly in the earth's equatorial plane. Further, owing to disc action, or the fact that rotating bodies attract like a disc and not like a material point, this ring will eventually be absorbed by the earth. Owing to tidal action, all systems, no matter how complicated, continually tend to assume a common angular velocity for all of their parts. Now this is impossible unless the system is reduced to two bodies. Hence all systems, our own included, will, by a process of successive consolidations, be eventually reduced to two bodies. But when a system has been reduced to two bodies, it will be immortal, for here we have perfectly stable motion which can only be disturbed by a third body. Perhaps this has some connection with the fact that binary systems seem to be a favorite fashion in the skies.

We have traced the future of the earth-moon system. Let us now attempt to retrace the past. The earth and moon are now separating, but they were certainly much nearer in the past. Equation (2) supposes that the earth attracts like a material point and its use can lead

to no appreciable error in regard to the future where the distances are great, but it cannot be applied when the bodies are near. However, let us suppose that it is so applicable and note the results. At the point A in Figure 2, we find that ϕ' and θ' have a common value of about 27.5, or the common period is about 5½ hours, and the distance between earth and moon is about 10,000 miles. This is within the critical distance and the moon could not exist as a single body, but must be a swarm of meteors. We suppose, however, that the earth exists as a single body, although in tracing back to an original identity of periods, the underlying idea is that the identity springs from the fact that earth and moon are one and the same body, or rather parts of that body. If the earth is surrounded by a ring of meteors within the critical distance, disc action will distribute the meteors uniformly in the ring and will eventually absorb them, just as Saturn is now absorbing its rings. By reason of its symmetry, such a ring can exert no tidal action on its primary and, therefore, there can be no counteraction driving the ring outward. In other words, from such an original condition there could have been no evolution of the moon to its present condition. Using equations (1) and (2), we find that if the moon, considered as a single body, were just grazing the surface of the earth, it would revolve in about 1½ hours, while the earth would rotate in about 4½ hours.

Darwin's hypothesis, which he termed "a wild speculation, incapable of verification," viz., that the moon was torn out of the earth by centrifugal forces, is therefore impossible. It is probable that the materials of the earth and moon were separated by centrifugal forces, but this could not have been delayed until after the earth had consolidated into a solid body.

Equation (2), which is

$$D^3\,\theta'^2 = m + m',$$

where m and m' are the masses of the earth and moon, can be modified for disc action by supposing that m continually increases as the bodies near each other. A rough estimate then gives us identity of periods in the past when the bodies were somewhere around 20,000 miles apart. Supposing that this identity was because the matter of the earth and moon were parts of the same lens of meteoric matter and that the moon ring separated at this distance, we have no difficulty in connecting such an origin with the present state of affairs. We may remark that such a lens of matter must rotate with a nearly common angular velocity, since the central attraction is nearly as the distance from the centre, while the centrifugal force is the same, and for stable motion the whole body must rotate nearly as a rigid body.

We may summarize our attempts to trace the past history of the earth-moon system as follows:

Using momental equation (1), and Kepler's equation (2) modified for disc action, we find that when the centres of the two bodies were roughly 20,000 miles apart there was a coincidence of periods. The dis-

tance may have been only 16,000 miles, but it was certainly well outside of the critical distance. Theoretically we know that there could not have been any moon unless the period of identity occurred outside of the critical distance. But besides this we have positive numerical proof that it did. Our curves in Figure 2 begin and end with identical periods at *A* and *B*, and they do not extend beyond these points, since with identity of periods all tidal action ceases. Since in a rotating lens-shaped swarm of meteors every particle tends to have the same period, we conclude that the matter of the earth and moon once formed such a swarm. The moon ring separated at a distance of something like 20,000 miles from the centre. The central matter now began to contract into the present earth, the rotation increasing with the contraction and being uninfluenced by the symmetrical moon ring. The moon ring, now well outside the critical distance, consolidated into the present moon. Tidal action now began and the present condition of the system fits numerically into such an origin.

Small bodies may have any shape by virtue of molecular cohesion, but beyond a certain size molecular cohesion becomes insignificant in comparison with the forces of self-gravitation which cause the molecules of all bodies to flow over each other, the surfaces of such bodies becoming equipotential surfaces for the forces acting upon them. Thus a large mass left to itself, flows into a sphere, no matter whether it is composed of steel, tallow, or water. The rigidity of the substance, which depends upon its molecular cohesion, does not enter into the question, except at the surface. A mass of steel, the size of the moon, would flow into a sphere, and while at the surface it would retain the character of steel, under the enormous pressure at the centre, it would not be steel in a physical sense, and probably not in a chemical sense. Any large rotating mass becomes a spheroid, having a surface which is equipotential for the self-gravitative and centrifugal forces.

If another body is near such a rotating mass, its surface becomes equipotential for three sets of forces, viz., self-gravitational, centrifugal and tidal forces.

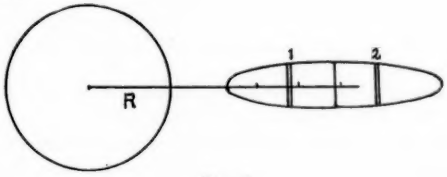


Fig. 3

Figure 3 represents a satellite revolving about a planet. Its centre is at a distance from the planet's centre equal to 2.86 times the radius of the latter. The planet is supposed spherical ,but the satellite is drawn out by tidal forces into a prolate ellipsoid of revolution, having its long axis 4.3 times the short axis.

All satellites are prolate ellipsoids, the elongation increasing as the distance from the primary decreases. In high-powered telescopes the 2nd and 3rd satellites of Jupiter can be distinctly seen to be long ellipsoids with their long axes pointing towards the primary. The moon is such an ellipsoid and the long axis points, on the average, to the earth's centre, but the sun's attraction causes this axis to "librate."

Let 1 and 2 be two laminæ of the satellite at equal distances, x, from the centre, and let D be the distance between the centres of the two bodies. Then the attraction of the planet on lamina 1 is

$$(M\,m/D^2)+(2\,M\,m/D^3)\,x,$$

while the attraction on lamina 2 is

$$(M\,m\,/D^2)-(2\,M\,m/D^3)\,x,$$

M and m being the masses of the two bodies. The combined attractions are the same as if the masses were concentrated at the centre, as must be the case if the total attractional forces are to balance the total contrifugal forces and thus enable the satellite to preserve a constant distance. But the differential forces, plus and minus $\frac{2\,M\,m}{D^3}x$, called tidal forces, tend to pull the laminæ apart, and if the body is to keep whole this pull must be counteracted by self-gravitation or molecular cohesion. The body is so large that molecular cohesion is negligible. Let a be the long semi-axis and b the short semi-axis. It can be shown that such a tidally distorted satellite is very nearly a prolate ellipsoid of revolution, and we shall so consider it.

Now it can be readily shown that the total tidal pull on one half is $\frac{M\,m}{2\,D^3}\,\frac{3}{4}\,a$, with an equal tidal pull on the other half, and these equal and opposite pulls tend to rupture the body at the central section. Let θ' be the rotational and revolutional velocity of the satellite. By Kepler's third law $\theta'^2=\frac{M}{D^3}$, nearly, and it can be easily proved that the total centrifugal force acting on each half is $\frac{M\,m}{2\,D^3}\,\frac{3}{8}\,a$

These disrupting pulls must be counteracted by the self-gravitation of the two halves if the body is to remain whole. The two halves attract each other the same as if their masses were concentrated into their centres of inertia, and the centre of inertia is $3a/8$ from the centre, or the centres of inertia are $3a/4$ apart. By equating the forces, we find that at the rupturing limit

$$\frac{M}{m\,D^3}=\frac{64}{81a^3},\quad \text{or}\quad \frac{R^3}{D^3}=\frac{64}{81}\,\frac{b^3}{a^3} \tag{3}$$

for equal densities.

Now the satellite has a surface which is equipotential for the three sets of forces we have considered, or the sum of the three potentials must be constant over its surface. The self-gravitational potential over the surface of such an ellipsoid is

$$V = \frac{3m}{2(a^2-b^2)^{1/2}} \log \frac{\sqrt{a^2-b^2}+a}{b}$$

$$-\frac{3}{2}\frac{m x^2}{(a^2-b^2)^3}\left[\log\frac{\sqrt{a^2-b^2}+a}{b} - \frac{\sqrt{a^2-b^2}}{a}\right]$$

$$-\frac{3}{4}\frac{m y^2}{(a^2-b^2)^{3/2}}\left[\sqrt{a^2-b^2}\,\frac{a}{b^2} - \log\frac{\sqrt{a^2-b^2}+a}{b}\right]$$

The rotational potential is

$$\frac{x^2+y^2}{2}\cdot\frac{M}{D^3}$$

and the tidal potential is

$$\frac{M}{D^3}\left(x^2-\frac{y^2}{2}\right)$$

We have taken a for the x axis and b for the y axis. Equating the sum of these potentials at the end of the a axis to the sum at the end of the b axis, we have

$$\left(a^2+\frac{b^2}{2}\right)\log\frac{\sqrt{a^2-b^2}+a}{b} - \frac{3}{2}a\sqrt{a^2-b^2} = \frac{M}{m D^3}a^3(a^2-b^2)^{3/2}$$

Designating the ratio of the axes a/b by q we have

$$\left(q^2+\frac{1}{2}\right)\log\left(\sqrt{q^2-1}+q\right) - \frac{3}{2}q\sqrt{q^2-1} = \frac{R^3}{D^3}q\,(q^2-1)^{3/2}$$

This gives us the shape of the satellite corresponding to any distance D. Thus at a great distance, the value of q is unity, and the satellite is a sphere. At the rupturing limit $R^3/D^3 = 64/81q^2$. Substituting this value we have.

$$\left(q^2+\frac{1}{2}\right)\log\left(\sqrt{q^2-1}+q\right) - \frac{3}{2}q\sqrt{q^2-1} = \frac{64}{81}\frac{(q^2-1)^{3/2}}{q}$$

Now $q = 4.3$ nearly satisfies this equation, and we find that at the rupturing point the satellite has been drawn out into a long ellipsoid with its major axis nearly 4.3 times the short axis, while the critical distance is $D = 2.86\,R$ for equal densities.

Let us now take a different problem:

Suppose two bodies, differing considerably in size, to approach each other, but without any rotation. We proceed as before merely leaving

out the rotational potential. We obtain the equation,

$$(q^3+\tfrac{1}{2})\log(\sqrt{q^2-1}+q)-\frac{3}{2}q\sqrt{q^2-1}=\frac{2}{3}(q^3+\tfrac{1}{2})\frac{(q^2-1)^{3/2}}{q}\cdot\frac{R^3}{D^3}$$

Now without any rotation, where the contest is simply between the tidal forces and those of self-gravitation, the rupturing point is determined by the equation $R^3/D^3 = 32/27q^2$.
Substituting this value, we have,

$$(q^3+\tfrac{1}{2})\log(\sqrt{q^2-1}+q)-\frac{3}{2}q\sqrt{q^2-1}=\frac{2}{3}\cdot\frac{32}{27}(q^3+\tfrac{1}{2})\ (q^2-1)^{3/2}/q^3$$

$q = 4.15$ nearly satisfies this equation. Hence at the breaking point, the long axis is nearly 4.15 times the short axis and the critical distance is $D = 2.44\,R$ for equal densities. This is known as "Roche's Limit." It does not apply to satellites, but only to non-rotating bodies. Roche demonstrated for the first time the surprising fact that if a body were brought within a certain distance of a considerably larger body, it would be split to pieces by the differential attractions. Or it would be reduced to pieces of such size as could resist further disintegration by molecular cohesion. A liquid mass, which has no molecular cohesion, would be reduced to veritable dust.

The title of his original paper, "La figure d'une masse fluide soumise á l'attraction d'un point éloigné" (Mém. Acad. de Montpelier, 1847-50), shows that it does not apply to rotating bodies. Strictly, he meant it to apply only to liquid bodies, but that is a matter of indifference, as above a certain size all bodies are fluid in the sense that they flow.

Roche's limit has been applied indiscriminately to rotating as well as non-rotating bodies. A rotating body, like a satellite, has besides tidal forces an additional disrupting force in the centrifugal force of rotation, and the distance at which a satellite will be torn to pieces is therefore appreciably greater than Roche's limit. I have given this limit for a satellite which is $D = 2.86\,R$ for equal densities. It may be remarked that the bursting of large aerolites in our atmosphere is due to tidal forces and not to unequal heating of the surface, the contest here being chiefly between tidal and cohesional forces.

If planet and satellite are both homogeneous but of unequal densities, this limit must be multiplied by the cube root of the ratio of the planet's density to that of the satellite. Actually neither planet nor satellite is homogeneous, but much denser towards the centre. This makes the critical distance appreciably less than the value we have calculated, viz., 2.86 times the planet's radius. Assuming Laplace's law of interior densities as nearly true, it is possible to calculate the actual limit in any case if we have reliable data. For Mars, the limit is certainly within 2.75 radii of the planet, for Phobos is at that distance and still intact. Likewise for Jupiter, the limit is under 2.6 radii, for the nearest satellite (the fifth) is at that distance. These satellites, however, are con-

stantly approaching their primaries, owing to disc action, and therefore must be nearing the limit. We can confidently expect that in some hundreds of years, more or less, they will be broken up into meteoric rings. There is little doubt that Saturn's rings were formed by an innermost satellite being drawn within the critical limit by disc action.

It is by no means *proved,* as is held in some quarters, that the zodiacal light is an appendage of the sun and not of the earth. It is possible that a meteoric zone surrounds the earth's equator, within the critical limit. A second moon may have been broken up by being drawn within this limit. While outside the critical distance this moon was a sphere with an exterior of rock and an interior of iron due to the great central compression, as in the case of our earth. While its rotation was being destroyed, melted material formed veins and dikes in its fractured rocks. Such a sphere, on being broken up by tidal action, would form a ring of angular, roughly-fractured, veined stone meteors for the most part, with a few angular iron meteors among them. We do not say that such was the case, but merely that it is possible. The ring, once formed, must gradually be absorbed by the earth, just as Saturn is now absorbing its rings. Fragments of rock from a few hundred pounds to a few grains in weight are continually raining down on the earth. Rarely a large mass of iron falls—larger than the stones because it can withstand a greater tidal stress.

We have been careful to state that tidal disruption occurs only when a body is near another comparatively larger body. Two equal bodies will not disrupt each other by approach. Where the densities and masses are not greatly disproportionate, the bodies will become ovoids, the ends of which will touch before disruption occurs. On a nearer approach, if it can be managed gradually, the bodies will flow into each other, and eventually become a sphere. The limiting relation between the masses and densities of two bodies which will just touch before disruption can be determined, although it is a complicated problem. It will be seen that a great variety of rotating doublets is possible. Two equal ovoids may rotate about their common centre of inertia, just touching, or they may be joined by a narrow neck, thus forming an hour-glass figure, or, when one is larger than the other, forming a pear-shaped figure, known as Poincaré's pear-shaped figure of equilibrium.

We have hitherto supposed that the axes of the rotating bodies were perpendicular to the orbit, as must be the case when the bodies are near each other. In the general case, however, the axes will be oblique. The axis of the tidal couple is always perpendicular to the orbit, but we can decompose this couple into two components, one acting about the rotational axis which tends to bring the rotational and revolutional velocities into coincidence, and another acting about an axis perpendicular to the rotational axis, which we shall call the gyroscopic component of the tidal couple. The effect of this latter couple is to cause the rota-

tional axis of the body to pendulate through a position of perpendicularity to the orbit, where it finally comes to rest. The moment of momentum of the system referred to its invariable plane remains constant, and any variations in the moment of a body, referred to this plane, are adjusted by variations in the distance between the bodies. Thus when the axis of a body in its pendulation becomes perpendicular to the orbit, the bodies approach, while, when the axis tilts, they separate.

Sir Robert Ball, followed by Lowell, has adduced as a reason that the axes of the planets must eventually fall into perpendicularity, the fact that energy is being continually dissipated, while the total moment of momentum must remain constant. They do not consider that the adjustment for momentum is effected by variations of distance, and in fact seem to think that the average distances between the bodies are invariable. When a planet has dissipated some of its rotational energy it obligingly, through no obvious cause, straightens up and thus brings into the principal plane the exact amount of momentum lacking.

If the system had started with all the axes perpendicular to the principal plane and had then dissipated its rotational energy, it would be in a sad plight regarding its moment of momentum, if it could not vary the distances.

Professor W. H. Pickering has suggested that the righting of the axes is effected through tidal action. That this is so, can be as rigidly demonstrated as any other fact in celestial mechanics. There is no reasonable doubt that the glacial and genial epochs of the earth's past history have been caused by the pendulation of the earth's axis.

Summary.

In three articles in this Journal ("Nebular Evolution," "Motion of a Particle about a Circular Disc," and the present article), we have traced the evolution of a celestial system as follows:

1. In some region of space which had previously been occupied only by the universal ether, there appear swarms of atoms. These atoms are at first of the lightest varieties: We have single-unit atoms (hydrogen), double-unit atoms (helium), triple-unit atoms (Rutherford's lithicon), quadruple-unit atoms, etc. How these atoms are formed from the ether, whether by pressure, or by what process, we do not know. *Ignoramus. Ignorabimus* ?

2. This swarm of atoms now begins a process of condensation and consolidation, by self-gravitation. Kelvin and Kant started here.

3. Heavier atoms are formed and heat develops in the central portions. Laplace started here.

4. Such a system possesses an invariable plane and an invariable amount of moment of momentum. If the rotational moment is slight the development will be into a globular star cluster. If the rotational

moment is excessive the result will be a ring. But in the great majority of cases, a lens-shaped rotating mass will be formed.

Usually this lens will collapse by thrusting out arms from diametrically opposite points, which, owing to the conservation of moments, results in a two-armed spiral. But the evolution of the lens may be a simple contraction with the detachment of rings. The lens may thus undergo a spiral or a Laplacian evolution, or both.

In our system, the four outer planets were formed from the arms of a bi-spiral, while the four inner planets were the result of the detachment of Laplacian rings from the remaining nucleus. The result was that the four outer planets had originally negative rotations, while the four inner planets had always positive rotations.

Tidal action will eventually bring all the axes perpendicular to the invariable plane with positive rotations.

5. This brings us to the present condition of the system, and the future is this: Tidal action will eventually result in a single common period. One by one, secondaries will be brought within the critical distance of their primaries and there be broken up, to be finally absorbed by the latter. When the system is finally reduced to two cold bodies, we have a stable condition of affairs where no further evolution is possible.

RELATIVITY

The World sails through an Einstein space,
Will wonders never cease?
With furious speed it whirls its way
While human thoughts increase.

Can one foretell, as time goes on,
The future of the race?
To Eons hence, when cold and dead,
The Sun shall furl his face.

When time and space can be combined
And interchanged as well;
Where there is neither up nor down,
And the *past* with the *future* dwell.

For the Sun, as he moves in his onward course,
May sometime return again
Through the star-strewn night of the infinite
To the lilt of the same refrain.

G. H. Hamilton

THE SOLAR ECLIPSE OF 1920 NOVEMBER 10 AS VISIBLE IN THE UNITED STATES

By WILLIAM F. RIGGE.

Tho solar eclipse of 1920 November 10 will be visible only over the northeastern half of the United States, and will take place in the early morning shortly after sunrise. The accompanying maps will give a fair idea of what is to be expected in any given place.

Fig. 1 is drawn for the beginning of the eclipse. The two curves *At Sunrise* and *Southern Limit of the Eclipse* need no explanation. The full lines marked from 7:50 to 8:20 show the central times of first contact for every ten minutes, from which the single minutes may be interpolated by proportion. The dashed curves N..... N30W give the position angles of the point of first contact as reckoned from the Sun's north point, while the dotted curves T.....T40E give them as reckoned from the Sun's top or vertex. The lines marked 6, 7, 8, at the bottom, show the central times of sunrise on that morning.

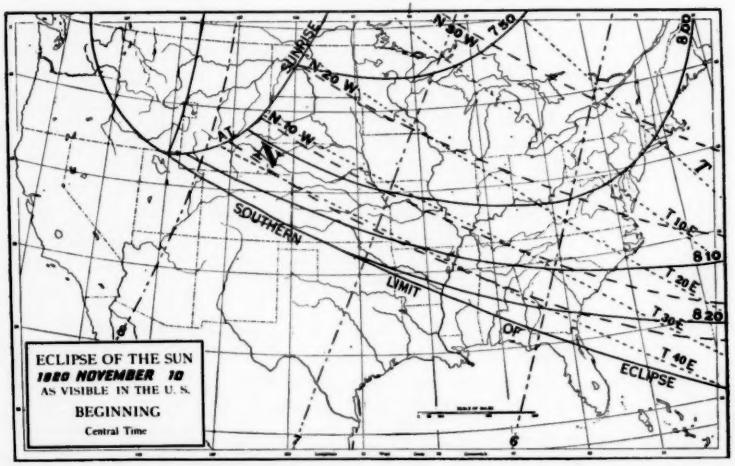


Fig. 1

Fig. 2 gives the times of the maximum obscuration from 8:20 to 9:00, while the curves 10, 20, 30, 40 show its percentage in fractions of the Sun's diameter covered by the Moon. The four drawings in the left lower corner show the corresponding appearances of the Sun.

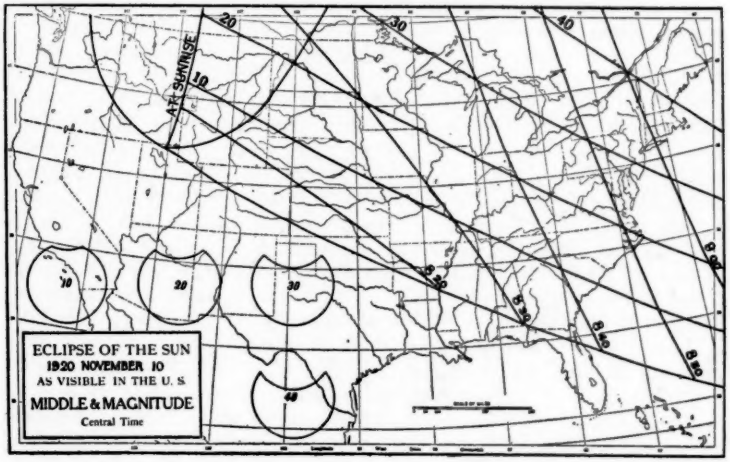


Fig. 2

Fig. 3 gives in the full lines the times of the end of the eclipse from 9:00 to 10:40, and in the broken ones the position angles of the point of last contact.

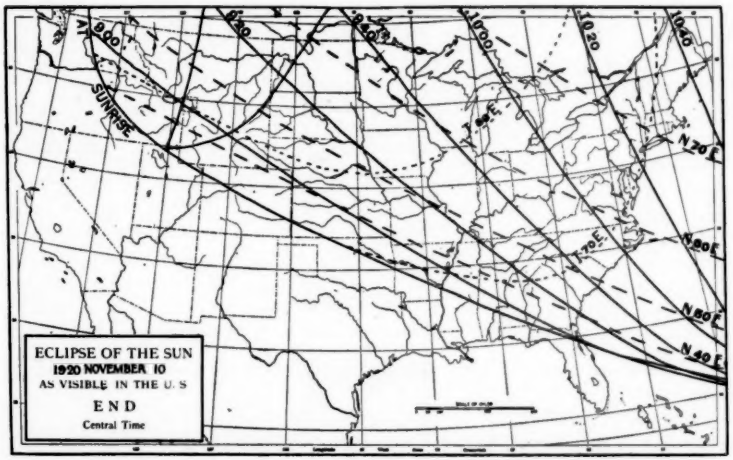
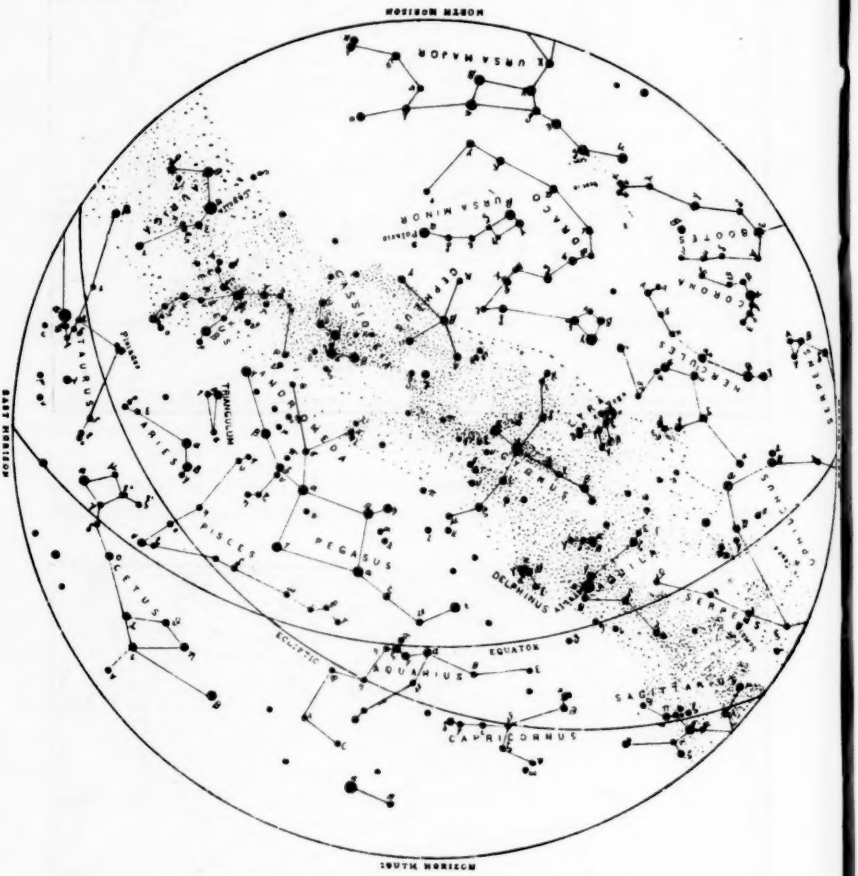


Fig. 3

PLANET NOTES FOR SEPTEMBER AND OCTOBER, 1920.

The *Sun* during these months descends from north 8° to south 14° declination, crossing the equator on September 23, when summer technically ends and autumn begins.



THE CONSTELLATIONS AT 9:00 P. M., OCTOBER 1.

The *Moon* will of course encircle the heavens twice during this period. Its phases will be as follows:

Last Quarter	September	5	at	1:05 P.M.	C.S.T.
New Moon		12	"	6:52 A.M.	"
First Quarter		19	"	10:55 P.M.	"
Full Moon		27	"	7:57 P.M.	"

Last Quarter	October	4	"	6:54 P.M.	"
New Moon		11	"	6:50 P.M.	"
First Quarter		19	"	6:29 P.M.	"
Full Moon		27	"	8:09 P.M.	"

The moon will be at apogee on September 20 and October 18, and at perigee on September 8 and October 4.

Mercury will be in conjunction with the sun on September 8 and so will be invisible during the first half of that month. In fact it will not come out from the solar rays far enough to be seen with the naked eye until after the middle of October. Mercury will be at greatest elongation, east from the sun 24° 08′, on October 24, about which time it may be seen toward the southwest after sunset.

Venus will be seen toward the southwest shortly after sunset during September and October. Its declination is further south than that of the sun so that it will not be in favorable position for northern observers. In the latter part of October, when Mercury is farthest from the sun, the two planets, Mercury and Venus, will not be far apart and it is possible that some of our readers may be able to see both of them at the same time. Conditions are much more favorable for observers in the southern hemisphere where the two planets will be much higher above the western horizon when they become visible in the twilight.

Mars has been within a few degrees of the first magnitude star Spica for the past two months, and even the most casual observer must have noticed the striking difference in color between the planet and the star, and the movement of the planet with reference to the star, first westerly then easterly. During October Mars will move steadily eastward through the constellations Scorpio and Ophiuchus. It will reach its greatest southern latitude in the constellation Sagittarius on the last day in October. On August 17 Mars will be in conjunction with the bright red star Antares (α Scorpio). The star and the planet are of very nearly the same color, and it would be hard to distinguish the one from the other except for the fact that the planet will be the brighter and the northernmost of the two.

Jupiter, having been in conjunction with the sun in August, will not be far enough out from the solar rays for satisfactory observation until October. It will then be seen toward the east a couple of hours before the sun rises. Jupiter's course lies through the constellation Leo, and it will be seen in the eastern part of that constellation when it emerges from the solar rays.

Saturn is in the same part of the sky with Jupiter, and will be in conjunction with the sun on September 7. It will be a little closer to the sun than Jupiter during October, and so will be in somewhat less favorable position for observation than Jupiter.

Uranus is in the constellation Aquarius about 10 degrees south of the well-known group of stars called the "Wye" of Aquarius. It is in its most favorable position for observation for this year during these two months, but is not plainly visible to the naked eye. It may be that some of our readers will be able to detect it with the aid of a small telescope.

Neptune is visible with the aid of a telescope, but it is in the part of the sky which is visible only in the morning. It is in the constellation Cancer not far from the Praesepe Cluster. Its disk is very small, and one would need a map of the fainter stars in order to detect it, even with the aid of a telescope.

Occultations Visible in the United States, September and October 1920

[NOTE:—Geographical positions are indicated by giving for each point, first the latitude, then the longitude, the two being separated by a hyphen. A line drawn on a map through the two or more points thus indicated will mark approximately the limit of the region of visibility for the United States.

The time given is the approximate Greenwich time of the middle of the occultation as seen from the United States.]

Sept. 4, 17h. 85 H.[1] Tauri, Mag. 6.0. East of long. 97° and southeast of 30°-97°, 35°-85°, 40°-73°.

Sept. 4, 19h. 234 B. Tauri, Mag. 6.0. South of 28°-90°, 35°-75°.

Sept. 4, 20h. ϵ Tauri, Mag. 3.6. South of 27°-103°, 33°-89°, 37°-75°.

Sept. 8, 23h. 84 B. Cancri, Mag. 6.4. South of 43°-128°, 48°-103°, 50°-85°, and west of 50°-85°, 38°-78°, 25°-76°. (Farther east occurs after sunrise.)

Sept. 9, 22h. ω Leonis, Mag. 5.5. East of 50°-115°, 42°-109°, 34°-99°, and north of 34°-99°, 36°-83°, 36°-65°.

Sept. 14, 13h. α Virg., Mag. 1.2. Throughout the U. S. except east of long. 76°. (West of 50°-96°, 40°-102°, 30°-107°, occurs before sunset.)

Sept. 16, 15h. 26 Lib., Mag. 6.3. West of 50°-110°, 40°-109°, 31°-112°.

Sept. 18, 14h. 68 B. Ophi., Mag. 5.9. North of 27°-124°, 30-100°, 36°-83°, 42°-69°.

Sept. 21, 12h. ρ Sag., Mag. 4.0. East of long. 75°. (Farther west, occurs before sunset.)

Sept. 22, 19h. 16 B. Cap., Mag. 6.2. Northwest of 25°-100°, 30°-88°, 33°-79°, and west of 33°-79° 40°-77°, 50°-79°.

Sept. 22, 19h. β Cap., Mag. 3.2. Northwest of 25°-105°, 30°-91°, 33°-81°, and west of 33°-81°, 40°-79°, 50°-81°.

Sept. 23, 18h. ν Aquarii, Mag. 4.5. Southeast of 38°-126°, 45°-112°, 50°-99°, and west of long. 70°.

Sept. 24, 11h. c^1 Cap., Mag. 5.3. East of long. 77°. (Farther west, occurs before sunset.)

Sept. 24, 11h. c^2 Cap., Mag. 6.3. East of 50°-85°, 42°-80°, 35°-75°. (Farther west, occurs before sunset.)

Sept. 26, 23h. λ Psc., Mag. 4.6. South of 33°-125°, 36°-105°, 37°-85°, and west of 37°-85°, 31°-82°, 24°-81°.

Sept. 30, 15h. 145 B. Ariet., Mag. 6.5. East of 25°-117°, 32°-120°, 39°-121°, and southeast of 39°-121°, 45°-106°, 50°-95°.

Oct. 2, 0h. 85 H[1]. Tauri, Mag. 6.0. South of 46°-125°, 47°-110°, 46°-96°, and west of 46°-96°, 38°-93°, 26°-92°. (Farther east, occurs after sunrise.)

Oct. 2, 17h. m Tauri, Mag. 5.0. Northwest of 34°-119°, 42°-98°, 50°-76°.

Oct. 3, 20h. 19 B. Gem., Mag. 6.2. Throughout the U. S.

Oct. 3, 21h. 71 Orion., Mag. 5.1. Florida, south of lat. 29°.

Oct. 4, 22h. λ Gem., Mag. 3.6. North of 40°-127°, 44°-105°, 43°-80°.

Oct. 5, 20h. 30 B. Cancri, Mag. 6.1. South of 32°-108°, 36°-90°, 39°-74°.

Oct. 6, 21h. κ Cancri, Mag. 5.1. East of 50°-116°, 38°-111°, 25°-102°.

Oct. 17, 11h. 39 G. Sag., Mag. 6.3. East of long. 90°. (Farther west, occurs before sunset.)

Oct. 19, 20h. g Sag., Mag. 5.1. South of 29°-90°, 32°-80°.

Oct. 20, 18h. 84 B. Cap., Mag. 6.0. South of 42°-128°, 47°-116°, 51°-98°, and west of 51°-98°, 40°-90°, 28°-87°.

Oct. 24, 20h. 25 Pisc., Mag. 6.2. East of 50°-103°, 38°-96°, 25°-87°. (Farther west, occurs before sunset.)

Oct. 25, 12h. 60 Pisc., Mag. 6.2. East of 50°-118°, 38°-112°, 25°-104°. (Farther west, occurs before sunset.)
Oct. 25, 21h. ϵ Pisc., Mag. 4.4. North of 44°-126°, 47°-105°, 47°-80°, 46°-67°.
Oct. 26, 22h. 26 B. Ariet., Mag. 6.0. Throughout the U. S.
Oct. 27, 16h. ρ Ariet., Mag. 5.8. Florida, south of lat. 29°.
Oct. 27, 19h. δ Ariet., Mag. 5.5. North of 30°-118°, 37°-99°, 40°-75°, 39°-63°.
Oct. 28, 1h. 145 B. Ariet., Mag. 6.5. West of 50°-100°, 40°-107°, 30°-116°. (Farther east, occurs after sunrise.)
Oct. 29, 0h. 163 B. Tauri, Mag. 5.8. South of 49°-125°, 46°-105°, 42°-88°. (East of long. 88°, occurs after sunrise.)
Oct. 29, 16h. 302 B. Tauri. Mag. 6.1. Throughout the U. S.
Oct. 29, 18h. *i* Tauri, Mag. 5.1. Throughout the U. S. except south of 26°-101°, 30°-89°, 32°-80°.
Oct. 29, 20h. 312 B. Tauri, Mag. 6.2. South of 28°-104°, 30°-87°, 29°-75.
Oct. 30, 2h. *m* Tauri, Mag. 5.0. North of 49°-125°, 45°-110°, and west of 45°-110°, 49°-109°. (Farther east, occurs after sunrise.)
Oct. 31, 22h. 110 B. Gem., Mag. 6.2. South of 35°-124°, 36°-107°, 35°-93°, 31°-77°.

ARTHUR SNOW,
Ass't. Nautical Almanac Office, U. S. Naval Observatory.

VARIABLE STARS.

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard time 6h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920 Sept.-Oct.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			24 21				31	10
SY Cassiop	0 09.8	+57 52	9.3— 9.9	4 1.7	7 16		23 23	10 5			26	12
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 13		19 1	4 13			20	1
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	14 22		29 17	14 12			29	7
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	8 11		24 8	10 5			26	2
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	4 21		24 11	10 2			25	16
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	9 20		24 10	9 0			23	13
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	9		25	11			27	
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	5 4		22 7	9 11			26	15
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 19		26 1	7 4			29	10
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	2 12		26 1	7 15			30	20
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	2 20		18 4	3 11			18	18
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	9 8		29 15	9 18			30	1
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	7 5		22 16	8 2			23	13
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	2 23		19 13	6 3			22	18
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	4 10		19 13	4 16			19	20
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	4 12			1 12			28	12
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	3 16		18 15	10 23			25	21
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	5 9		19 20	4 5			18	15
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	7 14		23 10	9 6			25	2
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 8		23 16	3 19			24	3
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5			18 5	10 11				
RR Gemin	7 15.2	+31 04	10.0—11.5	0 09.5	8 0		23 21	9 19			25	16
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	4 4		17 13	7 15			21	1

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920 Sept.-Oct.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	7 10	25 23	14 12	23 19				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	6 13	28 1	11 12	29 0				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0			6					
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	5 22	19 12	9 20	23 10				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	8 13	21 18	11 14	24 19				
S Muscæ	12 07.4	−69 36	6.4— 7.3	9 15.8	3 7	22 15	2 6	21 14				
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	8 16	24 15	10 13	26 12				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	8 3	21 14	4 1	24 6				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	8 9	20 1	7 12	25 0				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4 20	23 17	7 19	21 20				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	2 1	19 7	6 14	23 20				
SS Hydræ	25.0	−23 08	7.4— 8.1	8 04.8	9 15	26 0	12 10	20 20				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4 11	18 12	9 13	23 14				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	9 8	25 18	12 4	28 14				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	6 5	22 16	9 4	20 4				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	6 9	21 11	6 13	21 15				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	5 4	20 0	12 6	27 2				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	5 0	18 14	8 22	22 11				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	5 5	17 20	6 19	19 11				
S Normæ	16 10.6	−57 39	6.6— 7.6	9 18.1	9 21	29 9	9 3	28 16				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	3 22	21 16	9 9	27 2				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	5 11	23 16	11 21	24 0				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	3 13	17 14	8 15	22 15				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	11 3	28 6	15 9					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	4 15	19 20	12 14	27 19				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	8 9	19 22	7 6	18 19				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	8 20	22 7	12 20	26 1				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	9 5	19 13	10 6	20 14				
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	8 18	20 20	8 22	27 0				
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	5 4	23 13	11 23	24 6				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	8 10	20 8	8 4	26 0				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	7 8	25 13	4 15	22 19				
U Aquilæ	19 24.0	− 7 15	6.2— 6.9	7 00.6	6 13	20 14	11 16	25 17				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	7 19	21 19	12 19	26 19				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	3 7	19 6	13 5	29 4				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 21	18 6	3 15	19 1				
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	9 17	24 1	8 10	22 18				
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	1 20	18 15	13 18	30 12				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	8 4	20 19	9 18	22 9				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	10 2	26 11	12 20	29 5				
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	6 14	19 21	7 15	22 23				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	7 2	20 12	10 17	24 4				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	9 13	22 23	13 3	26 13				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	11 22	26 15	11 8	26 2				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	3 21	19 15	5 8	21 1				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	5 4	18 23	9 15	23 10				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	9 2	23 16	8 6	22 20				
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	4 16	21 23	8 6	26 14				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	6 5	22 7	8 9	18 4				
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	9 5	20 2	11 20	22 17				
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	6 9	19 5	8 11	21 7				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	9 0	23 23	8 22	23 21				
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	8 5	24 13	10 21	27 5				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	6 15	22 23	9 7	25 15				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	9 21	22 11	11 8	23 23				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	8 3	20 6	2 9	26 16				
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	3 12	17 11	8 10	22 9				

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 Sept.-Oct.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	10 21			15 19				
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	8 9	23 17		9 2	24 10			
UU Androm	38.5	+30 24	10.7—11.9	1 11.7	9 5	24 2		8 23	23 19			
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 21	22 20		7 19	22 18			
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6 23	19 5		7 13	25 21			
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	7 23	22 5		13 15	27 22			
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	7 3	20 20		11 10	25 3			
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	3 12	17 20		9 9	23 17			
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	4 5	22 19		10 8	27 21			
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	3 9	19 7		5 4	21 2			
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6		16 15		18 23				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	6 2	23 7		10 12	21 23			
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3 18	24 3		7 17	21 7			
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6 3	21 22		7 18	23 13			
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	7 15	24 6		10 20	27 10			
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	8 13	24 8		10 13	25 22			
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	10 16	23 21		7 2	20 7			
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	3 11	22 8		11 6	30 3			
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	12 11	24 21		7 7	19 17			
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	9 16	23 0		6 7	19 15			
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	5 23	22 8		8 16	25 1			
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	6 9	18 10		6 11	24 13			
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	7 2	24 10		11 18	29 2			
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	5 13	26 9		6 19	27 14			
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	5 7	21 8		7 8	23 9			
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	7 3	24 8		11 12	28 17			
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	4 15	21 10		13 20	30 15			
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	3 14	19 0		14 14	30 0			
RW Monoc	29.3	+ 8 54	9.0—10.8	1 21.7	7 11	22 16		7 23	23 4			
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	4 3	16 18		11 4	23 9			
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	8 13	22 21		14 9	28 17			
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	5 15	19 6		9 17	23 8			
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	4 14	23 4		11 18	30 9			
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	5 16	18 22		8 18	21 23			
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	2 1	18 20		5 15	22 10			
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	9 7	22 3		11 10	24 7			
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	9 5	23 18		8 7	22 20			
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	4 12	20 18		6 23	23 5			
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	10 1	29 0		8 12	27 11			
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	3 5	16 22		7 11	21 3			
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	6 14	18 11		6 6	18 3			
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5 4	18 16		8 21	22 9			
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	9 2	22 22		7 18	22 14			
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	9 11	22 16		12 11	25 16			
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 5	25 19		4 14	22 5			
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	2 21	17 13		9 13	24 5			
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	8 6	28 15		12 5	25 18			
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	4 14	19 14		4 14	19 14			
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	3 8	22 12		11 17	30 21			
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	4 9	26 16		11 13	26 2			
133026 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	6 9	23 17		11 2	22 17			
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	5 1	19 0		9 23	23 22			

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 Sept.-Oct.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	7 8	21 3	11 20	25 16				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	9 10	26 6	4 16	21 12				
SS Librae	15 43.4	—15 14	9.3—11.5	0 18.4	3 9	18 17	11 16	26 23				
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	5 15	27 15	12 8	19 16				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	3 8	19 20	14 14	31 2				
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	6 12	24 5	11 22	29 15				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	5 23	26 17	17 11					
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	8 18	22 8	12 18	26 8				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6 0	22 18	9 13	26 7				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	8 16	20 23	9 10	21 18				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	6 2	24 16	13 4	25 13				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	6 4	20 22	5 16	20 10				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	9 12	25 21	12 5	28 14				
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	5 6	20 8	5 10	20 11				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 23	20 11	13 16	29 4				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	9 3	25 3	11 2	27 1				
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	3 5	20 6	7 7	24 8				
WY Sagittarii	17 54.9	—23 1	9.5—10.6	4 16.0	3 21	22 13	11 6	20 14				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	2 14	23 7	3 15	24 7				
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	4 4	18 16	10 10	24 21				
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	5 8	19 4	9 21	23 17				
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	7 1	22 3	7 7	22 10				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	2 23	28 11	5 15	19 23				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	9 6	23 12	14 20	29 1				
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	7 19	24 9	11 0	27 15				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	4 18	21 18	8 17	25 17				
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	4 19	18 2	1 8	21 7				
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8	5 16	18 14	1 12	14 10				
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	7 5	21 12	7 18	30 16				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4 8	19 11	4 15	19 18				
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	7 12	21 21	13 12	27 21				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	8 6	28 4	5 3	23 0				
U.Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	5 4	18 17	15 18	29 7				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	6 6	20 23	13 2	27 19				
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	7 4	17 16	3 9	24 9				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5 2	24 15	7 17	20 18				
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	5 5	23 5	11 6	23 6				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	3 16	23 13	13 11	26 17				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	6 18	25 1	4 4	22 11				
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	2 5	27 12	14 9	22 19				
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	6 9	26 18	3 13	23 21				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 1	20 20	4 15	18 10				
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	3 4		10 23					
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	3 18	22 23	12 5	31 10				
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	7 18	26 3	14 13	23 17				
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	4 1	26 12	11 11	26 11				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	8 2	23 7	8 11	23 16				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2 3	22 8	12 12	22 15				
VVCygni	21 02.3	+45 23	12.1—13.8	1 11.4	5 5	19 23	4 18	19 12				
AE Cygni	09.0	+30 20	10 8—11.4	0 23.3	7 23	17 16	16 18	26 11				
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	4 13	20 7	12 22	28 15				
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	1 12	21 19	12 2	22 5				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3			1 8					
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	3 23	19 13	10 6	20 15				
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	6 7	14 14	9 11	17 18				
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	1 9	16 11	1 12	16 14				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	1 22	26 15	13 3	29 15				

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, April 20 to June 20, 1920.

This double report contains especially fine lists from Messrs. Lacchini, McAteer and Peltier. Mr. Lacchini's observations of U Geminorum 074922 and SS Cygni 213843, again illustrate the advantage of having observers located in different longitudes. SS Cygni rose to maximum on June 17 after an interval of 34 days, and may be expected to rise again on or about August 3.

The Association welcomes this month the observations of an observer located in Japan, Dr. Issay Yamamoto, "Ym", of Kyoto Observatory; and we shortly expect to have another observer there of proven ability, Miss Louise F. Jenkins, who has been at Mount Holyoke College, and who sails as a missionary in August. She will use the telescope so kindly loaned the Association by Mr. and Mrs. C. W. Elmer; the best wishes of all go with her in her new work. The Secretary, Mr. Olcott, has again found it possible to take up active observing, although he will be forced to discontinue during the summer when he takes a trip through Nova Scotia. Messrs. Brown, Henckel and Woglom also resume active observing this month.

Mr. A. C. Perry, of New York, has been elected to life membership. The following have been elected Active Members:

R. N. Buckstaff,	Oshkosh, Wis.
John Koep,	Chippewa Falls, Wis.
H. J. Long,	Owingsville, Ky.
D. H. Menzel,	Denver, Colo.
Dean Potter,	Leonia, N. J.
G. S. Rainey,	La Fayette, Ind.
D. Rasadeau,	Elizabeth, N. J.
A. L. Wallon,	Syracuse, N. Y.

Mr. Potter celebrates his affiliation by contributing fifteen observations, made with his 3-inch Clark. These are designated by the initial "Po".

Through the generosity of Professor S. A. Mitchell, of Leander-McCormick Observatory, and Mr. W. T. Olcott, the Association is the possessor of a splendid 3¼-inch refractor, to be known as the Mitchell-Olcott glass, and which will be loaned to one of our most promising members. We now have 14 instruments under our control, and good results are being obtained with nearly all of them. The President and the Recording Secretary made a visit to the contingent of members located at Nashua-Hudson, N. H., on June 8. There are five members in that locality, and the interest and activity displayed by all is most encouraging. The response of the subscription fund of the Chart Committee, for the printing of the new charts which are proving so valuable, continues to grow, and illustrates another way in which those unable themselves to observe are extending material aid to the active observers.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
001046	X Androm.	2473.8	<12.8	M.									
001726	T Androm.	2471.8	8.6	M,	2491.8	9.5	Pt.						
001755	T Cassiop.	2430.3	9.4	L,	2456.6	10.3	L,	2459.8	9.8	M,	2467.8	10.7	M,
		2470.6	10.7	L.									
003179	Y Cephei	2476.8	9.5	M.									
004047	U Cassiop.	2466.8	8.4	Pt,	2473.8	8.4	M.						
004132	RW Androm.	2474.8	10.8	M.									
004435	V Androm.	2474.8	11.1	M.									
004533	RR Androm.	2473.8	9.7	M.									
004746a	RV Cassiop.	2473.8	11.0	M.									
004746b	— Cassiop.	2473.8	10.7	M.									
004958	W Cassiop.	2471.8	9.1	M,	2488.8	11.7	Pt.						
010940	U Androm.	2494.8	11.4	M.									
011272	S Cassiop.	2450.6	8.5	Pt,	2471.8	9.1	M,	2488.8	9.2	Pt.			
013238	RU Androm.	2395.1	<11.0	Ch.									
013338	Y Androm.	2395.1	<11.0	Ch.									
014958	X Cassiop.	2471.8	11.5	M.									
015354	U Persei	2471.8	8.3	M,	2488.8	8.5	Pt.						
021024	R Arietis	2420.3	7.9	L.									
021281	Z Cephei	2466.8	<11.0	M.									
021403	o Ceti	2395.1	9.6	Ch.									
022813	U Ceti	2396.1	7.7	Ch.									
022980	RR Cephei.	2420.3	11.7	L,	2430.3	10.3	L,	2451.4	10.2	L,	2459.6	10.6	L,
		2466.6	10.6	L,	2466.8	10.4	M.						
024356	W Persei	2436.6	10.5	Pt,	2488.8	10.4	Pt.						
032043	Y Persei	2436.6	9.6	Pt.									
032335	R Persei	2436.6	8.7	Pt.									
043065	T Camel.	2430.3	9.1	L,	2454.4	8.6	L,	2470.5	8.2	L.			
043274	X Camel.	2436.6	12.5	Pt,	2450.6	12.2	Y,	2474.8	10.3	M,	2484.6	8.8	Pt.
		2486.6	8.5	Y.									
045514	R Leporis	2420.1	7.2	Ch,	2422.3	7.5	L.						
050953	R Aurigae	2436.6	7.5	Pt,	2436.6	8.2	V,	2450.6	7.4	Pi.			
052034	S Aurigae	2420.3	9.5	L,	2429.4	9.8	Ja,	2440.3	9.9	L,	2454.3	10.0	L.
052036	W Aurigae	2422.3	12.0	L,	2429.4	12.5	Ja,	2454.3	<11.5	L.			
053005a	T Orion.	2422.3	10.0	L,	2431.8	9.8	L_2,	2436.6	9.5	Pt.			
053068	S Camel.	2436.7	8.3	Pt,	2484.6	9.5	Pt.						
053531	U Aurigae	2436.6	10.7	V,	2450.6	11.4	Y,	2450.6	11.2	Pt.			
054319	SU Tauri	2420.3	9.4	L,	2429.4	9.3	L,	2433.3	9.5	L,	2434.6	9.5	B
		2436.6	9.5	V,	2440.3	9.3	L,	2450.6	9.7	Y,	2451.3	9.4	L,
		2454.3	9.4	L.									
054920	U Orion.	2395.2	<11.0	Ch,	2420.1	12.0	Ch,	2450.6	10.3	Pt.			
054974	V Camel.	2312.0	<13.0	Ym,	2374.0	<13.5	Ym,	2403.0	11.3	Ym,			
		2436.7	11.0	Pt,	2450.6	11.2	Y,	2466.8	10.9	M,	2484.6	12.3	Pt,
		2486.6	12.2	Y.									
055353	Z Aurigae	2422.4	11.0	Ja,	2429.4	10.9	Ja,	2450.6	10.8	Pi.			
060450	X Aurigae	2422.4	12.2	Ja,	2429.4	11.6	Ja,	2450.6	9.4	Pi.			
060547	SS Aurigae	2314.0	<14.0	Ym,	2334.0	<14.0	Ym,	2335.0	<13.5	Ym,			
		2351.0	<13.3	Ym,	2374.0	11.0	Ym,	2375.0	11.0	Ym,			
		2378.9	13.1	Ym,	2397.0	<12.5	Ym,	2403.0	<14.0	Ym,			
		2416.3	<11.5	L,	2420.3	<13.3	L,	2421.4	<12.6	Ja,			
		2422.1	<11.5	Ch,	2422.3	<13.3	L,	2428.3	<13.0	L,			

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D. Est. Obs. J.D. Est. Obs. J.D. Est. Obs. J.D. Est. Obs.
060547	SS Aurigæ	2429.3<12.4 Pe, 2429.4<13.3 Ja, 2429.4<13.3 L, 2430.3<12.4 Pe, 2430.4<13.3 L, 2431.3<13.0 L, 2433.3<13.3 L, 2434.3<12.4 L, 2435.5<12.5 Cl, 2436.6 10.9 Pt, 2436.6 10.8 V, 2437.6 11.3 Pt, 2439.3 10.8 L, 2440.3 10.8 L, 2440.5 10.7 Cl, 2443.3 11.0 L, 2443.6 11.0 Pi, 2447.5 12.4 Ya, 2447.6 12.5 Ba, 2447.6 13.0 Pi, 2450.5<12.4 Jd, 2450.6<12.6 Pt, 2450.6<12.4 Pi, 2450.6<13.3 Y, 2450.6<12.8 Cl, 2451.3<13.3 L, 2453.6<11.4 V. 2454.5<12.4 E, 2454.6<12.6 Pt, 2456.3<12.4 Pe, 2466.6<12.4 Pt, 2472.6<12.5 Ba.
063159	U Lyncis	2450.6 9.9 Y, 2486.6 9.8 Y
063558	S Lyncis	2436.6 12.8 Pt.
064030	X Gemin.	2429.3 9.0 Ja, 2436.6 9.2 V.
065111	Y Monoc.	2431.4 9.4 Ja, 2450.6 9.5 Pi.
065208	X Monoc.	2422.3 8.0 L, 2433.3 8.4 L.
065355	R Lyncis	2450.6 7.8 Pt, 2450.6 7.8 Y, 2484.6 8.3 Pt, 2486.6 8.7 Y.
070109	V Can. Min.	2431.4<12.2 Ja.
070122a	R Gemin.	2395.2 10.4 Ch, 2422.2<11.5 Ch, 2429.3<12.3 Pe.
070122b	Z Gemin.	2395.2 10.6 Ch.
070122c	TW Gemin.	2429.3 8.3 Pe.
070310	R Can. Ven.	2420.3 8.6 L, 2431.3 8.5 L_2, 2431.4 8.4 Ja, 2434.6 8.1 B, 2450.6 9.1 Pi, 2451.3 9.2 L.
071044	L_2 Puppis	2426.1 4.5 Ch.
071713	V Gemin.	2436.6 9.9 Pt, 2450.6 11.9 Pi.
072708	S Can. Min.	2395.2<11.0 Ch, 2428.2<11.0 Ch, 2429.3 12.1 Pe, 2432.5 11 Ro, 2455.3 9.9 Pe.
072811	T Can. Min.	2436.6 9.5 Pt.
073508	U Can. Min.	2436.6 10.0 Pt, 2450.6 9.1 Y.
073723	S Gemin.	2450.6<12.4 Pi, 2450.6 12.0 Pt.
074323	T Gemin.	2436.6<11.5 V, 2443.6 10.5 Pi, 2447.6 9.7 Ya, 2450.6 10.0 Pi, 2453.6 10.1 V, 2461.6 9.2 Pi.
074922	U Gemin.	2416.3<10.9 L, 2420.3<12.4 L, 2422.3<13.3 L, 2428.3<13.3 L, 2429.4<13.3 L, 2429.4<13.3 Ja, 2430.4<13.3 L, 2431.3<12.4 L, 2431.4<13.3 Ja, 2433.3<13.3 L, 2434.3<12.4 L, 2436.6<11.7 V. 2436.6<12.4 Pt, 2437.6<12.4 Pt, 2439.3<11.4 L, 2440.3<11.7 L, 2443.3<11.5 L, 2446.3 9.4 L, 2447.6 9.5 Pi, 2450.6 9.6 Pi, 2450.6 9.2 Pt, 2450.6 9.5 Y, 2451.3 9.2 L, 2451.6 9.3 Y, 2453.3 9.8 L, 2453.6 9.8 V, 2453.7 10.0 Pt, 2454.3 9.8 L, 2454.6 10.3 Ba, 2454.6 10.1 Pt, 2455.3 10.7 L, 2456.3 11.5 L, 2457.3 12.3 L, 2458.3 12.3 L, 2461.6<11.7 Ya, 2461.6<13.3 Ba, 2461.6<12.4 Pi, 2462.6<13.3 Y, 2472.6<12.4 Ba.
081112	R Cancri	2383.1 6.8 Ch, 2391.1 6.5 Ch, 2400.1 6.2 Ch, 2408.2 6.0 Ch, 2428.2 6.5 Ch, 2436.6 6.2 Pt, 2461.6 7.2 Ba.
081617	V Cancri	2429.3 13.0 Ja, 2461.6 10.4 Pi, 2461.6 10.1 Ba.
082405	RT Hydrae	2430.3 8.0 L, 2454.3 8.3 L.
083019	U Cancri	2436.6<11.1 V, 2461.6<13.3 Ba.
083350	X Urs. Maj.	2461.6<13.5 Ba.
084803	S Hydrae	2391.1 7.7 Ch, 2400.1 7.9 Ch, 2408.2 8.6 Ch, 2428.2 9.1 Ch, 2436.6 9.9 Pt, 2461.6 11.1 Ba.
085008	T Hydrae	2395.1<11.0 Ch, 2430.4<12.2 L, 2461.6<12.5 Ba.
085120	T Cancri	2430.4 9.6 L, 2451.3 9.6 L, 2461.6 9.8 Pi, 2461.6 8.5 Ba, 2464.4 9.5 L.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
090151	V Urs. Maj.	2430.4	10.6	Pe,	2456.3	10.5	Pe,	2482.7	10.2	Mu.			
090425	W Cancri	2451.3	<12.6	L,	2461.6	<13.7	Ba.						
093014	X Hydrae	2461.6	10.4	Ba.									
093178	Y Draconis	2450.6	<13.6	Y,	2471.6	<13.0	Ba,	2486.6	13.4	Y.			
093934	R Leo. Min.	2430.4	7.8	L,	2436.6	7.9	Pt,	2447.6	8.2	M,	2450.5	8.7	Jd,
		2450.5	8.8	E,	2451.4	8.1	L,	2461.5	9.2	Pi,	2462.6	9.1	Ya,
		2464.4	9.3	L,	2468.6	8.8	Ba_2,	2475.6	9.5	M,	2482.6	9.6	Po,
		2484.6	9.7	Pt,	2485.6	9.5	Ya.						
094211	R Leonis	2382.2	6.4	Ch,	2391.1	6.0	Ch,	2400.1	6.2	Ch,	2429.2	6.8	Ch,
		2429.4	6.6	Bq,	2430.3	7.8	L,	2430.3	7.4	Pe_3,	2432.5	6.4	Ro,
		2436.6	6.7	Pt,	2437.5	6.4	Ro_2,	2447.6	7.2	M,	2450.3	8.1	Pe,
		2450.5	7.4	Jd,	2450.5	7.4	E,	2452.3	7.1	Ro_3,	2455.3	8.1	Pe,
		2458.0	7.8	Ro_4,	2460.6	8.0	Gd,	2461.5	7.1	Ba,	2461.5	8.2	Pi,
		2462.6	8.0	Ya,	2463.7	8.4	Mu,	2465.5	8.0	Ro_2,	2472.6	8.2	Pi,
		2474.7	8.5	Ml,	2475.6	8.0	M,	2482.6	8.9	Po,	2482.7	8.8	Mu,
		2484.6	8.5	Pt,	2484.6	8.5	O,	2485.6	8.3	Ya.			
095421	V Leonis	2429.4	13.0	Ja,	2430.4	<13.0	Pe,	2471.6	9.4	Ba,			
		2474.7	9.4	Ml,	2484.6	9.3	Pt.						
103212	U Hydrae	2420.3	5.0	L,	2429.4	5.4	Bq,	2430.4	5.3	L,	2451.4	5.0	L,
		2455.3	5.6	Pe,	2465.4	5.2	L,	2482.6	5.4	Bh.			
103769	R Urs. Maj.	2395.1	8.2	Ch,	2422.1	8.7	Ch,	2436.8	9.4	M,	2437.8	9.4	Pt,
		2454.6	10.5	Ba,	2461.5	10.8	Ba,	2463.6	10.7	Ya,			
		2466.7	10.8	Pt,	2466.8	10.9	M,	2471.6	11.2	Ba,			
		2490.6	11.8	Cl.									
104620	V Hydrae	2420.3	6.5	L,	2430.4	6.5	L,	2434.6	7.3	Ya,	2451.4	6.0	L,
		2462.6	7.4	Pi,	2468.4	6.0	L.						
104814	W Leonis	2447.6	12.4	M,	2461.6	12.8	Pi,	2462.6	12.9	Y,			
		2471.6	<12.5	Ba,	2485.6	13.0	Jk.						
115919	R Comae B.	2429.4	<13.0	Ja,	2454.6	10.5	Ba,	2461.6	9.8	Pi,	2461.6	9.5	Ba,
		2471.6	8.9	Ba,	2486.6	9.0	O.						
120012	SU Virgin.	2421.4	12.2	Ja,	2429.4	11.9	Ja,	2436.4	11.6	Ja,	2436.6	11.5	V,
		2445.4	10.9	Ja,	2453.6	10.8	V,	2455.8	9.8	Pe_2,	2461.6	9.7	M,
		2461.7	10.0	Pi,	2471.6	10.2	Ba,	2481.6	10.6	V,	2484.6	10.4	Pt,
		2489.7	10.2	M.									
121418	R Corvi	2430.5	12.5	Ja,	2461.6	11.0	Ba,	2462.6	10.9	Pi,			
		2471.6	10.5	Ba,	2484.6	10.4	Pt.						
122001	SS Virgin.	2422.3	7.6	L,	2431.4	7.8	L_2,	2431.5	8.8	Ja,	2440.6	8.6	L,
		2452.9	7.8	L_2,	2468.4	7.8	L.						
122532	T Can. Ven.	2436.8	9.0	M,	2461.6	9.1	Ba,	2461.7	9.5	Pi,			
		2466.8	9.7	M,	2482.6	9.5	Ya,	2487.7	9.5	Pt.			
122803	Y Virginis	2430.4	9.7	L,	2432.5	10.0	Ja_2,	2435.6	10.1	Cl,			
		2454.4	10.1	L,	2462.6	10.3	Pi,	2468.4	10.4	L.			
123160	T Urs. Maj.	2417.2	<11.0	Ch,	2439.8	<12.6	M,	2464.6	12.3	Jk,			
		2466.8	<12.3	M,	2471.6	12.6	Ba,	2484.7	11.8	Pt,			
		2485.6	12.1	Jk,	2485.6	11.5	Ya,	2490.6	10.5	Cl,			
		2490.6	11.0	K.									
123307	R Virginis	2430.4	10.8	L,	2436.6	10.1	Pt,	2440.6	9.6	L,	2454.4	8.1	L,
		2455.8	8.2	Pe_2,	2462.6	8.0	Ya,	2462.6	7.9	Pi,	2466.8	7.6	Pt,
		2467.9	7.2	L_2,	2471.6	7.7	Ba,	2474.7	7.7	Ml,	2486.6	7.5	O,
		2490.6	7.3	Ya,	2490.7	7.4	Po.						
123459	RS Urs. Maj.	2417.2	8.8	Ch,	2429.3	9.0	Pe,	2435.2	9.3	Ch,	2435.5	9.3	Cl,
		2436.6	9.8	Pt,	2436.8	9.3	M,	2463.6	11.1	Pi,	2463.6	11.1	Ya,
		2466.8	11.0	M,	2466.8	11.2	Pt,	2471.6	11.5	Ba,			
		2485.6	<11.3	Ya.									

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number Name	J.D. Est. Obs.	J.D. Est. Obs.	J.D. Est. Obs.	J.D. Est. Obs.
123961 S Urs. Maj.	2417.2 8.6 Ch,	2430.3 8.6 L,	2435.2 8.5 Ch,	2435.5 8.6 Cl,
	2436.6 8.6 Pt,	2436.7 8.3 V,	2436.7 8.3 Ga,	2436.8 8.3 M,
	2450.7 7.7 Ga,	2453.7 8.4 V,	2454.6 8.0 Ba,	2458.6 8.0 L_2,
	2463.6 8.2 Pi,	2463.6 8.3 Ya,	2464.6 8.2 Jk,	2466.5 8.1 L,
	2466.7 8.0 Pt,	2466.8 8.1 M,	2471.6 8.0 Ba,	2474.7 8.3 Ml,
	2481.1 8.2 O_2,	2481.6 8.3 V,	2482.7 8.5 Po,	2485.6 8.5 Jk,
	2485.6 8.7 Ya,	2490.6 8.8 K,	2490.6 8.6 Cl.	
124204 RU Virginis	2431.4<13.0 Ja,	2461.6 12.2 M,	2462.6 12.6 Pi,	2484.6 11.8 Pt.
124606 U Virginis	2432.0 8.6 Ja_2,	2436.6 8.4 Pt,	2456.3 9.2 Pe,	2461.6 9.1 M,
	2462.6 9.3 Pi,	2471.6 9.5 Ba,	2484.7 11.3 Pt.	
130212 RV Virginis	2461.6<12.5 M,	2471.6 10.8 Ba.		
132002 W Virginis	2462.6 9.3 Pi,	2471.6 10.0 Ba,	2490.7 10.0 Ya.	
132202 V Virginis	2461.6 9.5 M,	2462.6 10.2 Pi,	2471.6 9.8 Ba,	2474.7 9.6 Ml,
	2490.7 9.6 Ya.			
132422 R Hydrae	2430.4 9.5 L,	2436.3 9.7 Ch,	2436.6 9.4 Pt,	2451.4 9.3 L,
	2468.4 9.3 L,	2474.7 8.8 Ml,	2482.7 8.6 Pt.	
132706 S Virginis	2429.5 8.8 Ja,	2436.7 9.3 Pt,	2460.7 10.1 Gd,	2461.6 9.7 M,
	2462.6 9.8 Pi,	2471.6 9.9 Ba,	2484.7 10.9 Pt.	
134440 R Can. Ven.	2436.6 9.5 Pt,	2436.8 9.4 M,	2450.7 8.6 Pi,	2454.5 9.0 Ya,
	2454.5 8.8 E,	2462.6 8.6 Y,	2466.8 8.7 M,	2466.8 8.4 Pt,
	2471.6 8.3 Ba,	2474.7 7.8 Ml,	2482.6 8.3 Ya,	2482.7 8.3 Po,
	2486.6 8.2 Pi,	2490.6 8.1 Y.		
135908 RR Virginis	2430.5<13.1 Ja,	2471.6 11.4 Ba,	2487.7 11.6 Pt.	
140113 Z Bootis	2451.6<13.4 Y,	2467.8<11.9 M,	2486.6<12.6 Y.	
141567 U Urs. Min.	2463.6 8.8 Pi,	2471.6 8.5 Ba,	2483.7 8.6 Po,	2489.8 8.6 M,
	2493.8 8.6 Pt.			
141954 S Bootis	2420.3 8.8 L,	2440.3 9.1 L,	2450.6 8.8 Pt,	2450.7 9.0 Pi,
	2466.5 9.3 L,	2466.8 9.5 Pt,	2467.8 9.3 M,	2471.7 9.4 Ba,
	2483.7 9.6 Po,	2486.6 9.7 Pi.		
142205 RS Virginis	2429.4 8.3 Ja,	2434.5 8.3 Ja,	2445.5 8.5 Ja,	2472.6 8.5 Ba.
142539 V Bootis	2420.3 8.9 L,	2431.3 9.0 L,	2432.5 8.5 Ro,	2436.7 8.9 Pt,
	2436.8 8.5 M,	2437.5 8.6 Ro_2,	2439.3 9.1 L,	2450.7 9.3 Pi,
	2450.8 9.2 Ro_4,	2456.8 9.6 Ro_3,	2460.6 9.1 L,	2463.6 10.0 Pi,
	2466.8 9.1 M,	2471.2 9.8 Ro_4,	2472.6 9.5 Ba,	2488.6 10.5 Pi_2,
	2488.7 10.4 Pt,	2490.6 10.4 K.		
142584 R Camel.	2439.8 9.9 M,	2463.6 11.0 Pi,	2463.7 11.0 Ya,	2467.8 11.2 M,
	2472.6 11.5 Ba,	2485.7<11.2 Ya.		
143227 R Bootis	2436.6 10.3 Pt,	2436.8 9.7 M,	2450.5 10.7 E,	2454.6 10.3 E,
	2461.7 10.9 Pi,	2463.7 11.1 Ya,	2467.8 11.8 M,	
	2470.8 11.5 Pt,	2472.6 11.2 Ba,	2482.7 12.0 Ya,	
	2483.6 12.3 Pi.			
144918 U Bootis	2436.7<11.2 V,	2461.7 11.5 Pi,	2467.8 11.4 M,	2472.6 10.9 Ba,
	2481.6 10.4 V,	2488.7 10.7 Pt.		
150018 RT Librae	2436.7 12.5 Pt.			
150519 T Librae	2431.5<12.9 Ja.			
151432 U Cor. Bor.	2395.2 7.5 Ch.			
151520 S Librae	2398.3 8.4 Ch,	2408.2 8.3 Ch,	2413.4 8.2 Ch,	2425.2 8.5 Ch,
	2430.5 8.7 L,	2443.6 9.5 L,	2457.4 10.0 L.	
151714 S Serpentis	2458.6 12.2 L,	2461.7 12.3 Pi,	2467.8 12.1 M,	
	2471.6 11.5 L,	2472.6 12.2 Ba,	2478.7 11.6 Ml.	
151731 S Cor. Bor.	2395.2 8.6 Ch,	2429.2 10.1 Ch,	2436.7 10.3 Pt,	
	2436.7 10.1 V,	2451.6 10.0 Y,	2453 10.1 V,	
	2467.6 11.2 Pi,	2467.8 11.0 M,	2470.8 10.9 Pt,	
	2472.6 11.2 Ba,	2481.6<11.1 V,	2485.6<11.1 Po.	
151822 RS Librae	2430.5 11.8 L,	2443.6 11.7 L,	2457.4 10.9 L.	

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
153378	S Urs. Min.	2441.5	10.9	Ro_2,	2452.5	10.8	Ro_2,	2453.7	<11.2	V,			
		2457.2	10.9	Ro_4,	2463.6	11.2	Pi,	2467.8	11.7	M,			
		2472.6	10.7	Ba,	2473.5	<11.0	Ro,	2481.5	10.8	Ro,			
		2481.7	10.7	V,	2491.8	11.0	Pt,	2495.6	10.6	K.			
154428	R Cor. Bor.	2419.2	6.4	Ch,	2420.3	6.0	L,	2421.4	6.4	Ja,	2422.6	6.1	L,
		2429.3	6.1	Pe,	2429.4	6.0	L,	2430.4	6.2	Pe,	2430.4	6.0	L,
		2431.3	6.0	L,	2431.7	6.4	Mu,	2432.5	6.1	Ro,	2433.3	6.0	L,
		2433.7	6.3	Mu,	2434.6	6.1	L,	2436.5	6.4	Ro,	2436.6	6.0	Pt,
		2436.7	6.3	Mu,	2436.7	6.3	Ga,	2437.8	6.2	Pt,	2438.5	6.4	Ro,
		2439.3	6.0	L,	2439.6	6.1	Ga,	2439.8	6.0	Pt,	2440.6	6.0	L,
		2444.5	6.5	Ro,	2447.6	6.0	Ba,	2447.6	6.3	M,	2450.5	6.5	Ro.
		2450.6	6.0	Pt,	2450.7	6.3	Mu,	2450.7	6.0	Ga,	2451.4	6.1	L,
		2451.7	6.4	Mu,	2453.3	6.0	L,	2453.7	6.1	Pt,	2453.7	6.4	V,
		2454.5	6.6	Ro,	2455.4	6.3	Pe,	2455.5	6.2	Ro,	2455.7	6.5	Mu,
		2456.5	6.5	Ro,	2458.7	6.6	Mu,	2459.5	6.5	Ro,	2459.7	6.1	Pt,
		2459.8	6.5	Mu,	2460.6	6.1	L,	2460.6	6.2	Ya,	2461.6	5.8	Ba,
		2461.6	6.2	M,	2461.7	6.6	Mu,	2463.7	6.7	Mu,	2464.3	6.1	L,
		2464.5	6.5	Ro,	2465.4	6.1	L,	2466.5	6.3	L,	2466.8	6.2	M,
		2466.8	6.2	Pt,	2467.6	6.0	Pi,	2467.7	6.6	Mu,	2468.4	6.3	L,
		2468.5	6.7	Ro,	2470.5	6.3	L,	2470.8	6.1	Pt,	2471.5	6.3	L,
		2471.6	6.7	Bn,	2471.6	6.4	Ba,	2471.7	6.6	Mu,	2472.5	6.4	Ba,
		2472.6	6.7	Wg,	2472.8	6.2	M,	2473.5	6.4	Ro,	2473.8	6.4	M,
		2475.6	6.3	M,	2478.5	6.7	Ro,	2478.6	6.7	O,	2480.7	6.6	Mu,
		2481.5	6.6	Ro,	2482.7	6.0	Pt,	2482.7	6.4	Mu,	2483.6	6.6	Pi,
		2483.6	6.4	O,	2484.6	6.4	O,	2484.6	6.3	Pt,	2484.7	6.3	Mu,
		2485.6	6.7	Bn,	2485.8	6.3	M,	2486.6	6.3	Pi,	2487.6	6.1	Pt,
		2487.8	6.3	M,	2488.7	6.1	Pt,	2488.8	6.3	Mu,	2490.6	6.0	Hn,
		2490.7	6.4	Pi,	2490.7	6.6	Po,	2491.8	6.0	Pt,	2493.6	6.0	Pt,
		2493.8	6.5	M,	2494.6	6.1	Pt,	2494.6	6.7	Su,	2495.6	6.7	Bn,
		2495.6	6.5	K.									
154536	X Cor. Bor.	2447.6	9.7	M,	2453.7	9.3	V,	2466.8	9.1	M,	2472.6	8.6	Ba,
		2481.7	9.3	V.									
154615	R Serpentis	2421.4	7.0	Ja,	2427.2	6.6	Ch,	2429.8	7.1	Pe_2,	2432.0	7.2	Ja_2,
		2436.7	7.2	Pt,	2445.5	7.8	Ja,	2450.3	8.1	Pe,	2453.7	7.9	V.
		2455.9	8.2	Pe_2,	2461.6	8.2	M,	2461.7	8.4	Gd,	2463.7	8.9	Mu,
		2467.6	8.4	Pi,	2467.8	8.7	M,	2470.8	8.8	Pt,	2472.6	8.6	Ba,
		2474.9	8.6	Ml,	2481.7	8.8	V,	2482.3	8.7	O_2.			
154639	V Cor. Bor.	2436.7	10.2	Pt,	2447.6	10.8	M,	2463.6	11.4	Pi,	2466.8	11.2	M,
		2472.6	10.0	Ba,	2486.6	11.5	Pi,	2488.8	10.2	Pt.			
155018	RR Librae	2454.4	9.9	L,	2471.6	10.5	L,	2472.6	10.4	Ba.			
155229	Z Cor. Bor.	2472.6	11.4	Ba,	2487.8	11.0	M.						
160021	Z Scorpii	2430.5	11.3	L,	2458.6	12.0	L.						
160118	R Herculis	2430.5	<13.8	Ja,	2488.8	9.4	M.						
160210	U Serpentis	2436.7	11.4	Pt,	2439.8	12.0	M,	2451.6	<12.3	Y,			
		2486.6	<12.3	Y.									
160625	RU Herculis	2473.8	12.0	M,	2483.6	11.2	Pi,	2483.6	10.9	Po,			
		2487.6	10.5	Pt.									
161122a	R Scorpii	2429.6	<13.0	Ja,	2493.7	12.2	Pt.						
161122b	S Scorpii	2429.6	10.6	Ja,	2436.8	10.5	Pt,	2445.5	10.7	Ja,			
		2493.7	13.0	Pt.									
161122c	T Scorpii	2493.7	11.0	Pt.									
161138	W Cor. Bor.	2446.7	<11.2	Pi,	2461.6	11.4	M,	2462.6	10.9	Y,			
		2463.6	11.2	Pi,	2473.8	9.7	M,	2486.6	9.0	Pi.			
161607	W Ophiuchi	2439.8	10.7	M,	2440.6	<12.5	L.						
162112	V Ophiuchi	2429.6	8.3	Ja.									
162119	U Herculis	2396.2	<11.0	Ch,	2425.2	<11.0	Ch,	2471.8	12.0	M,			
		2483.6	<12.0	Pi.									

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
162807	SS Herculis	2461.7	9.4	M,	2472.8	10.1	M,	2486.6	10.5	O.			
163137	W Herculis	2396.2	10.2	Ch,	2436.7	12.5	Pt,	2462.6	13.2	Y,			
		2485.6	13.2	Jk.									
163172	R Ursae Min.	2436.8	9.5	M,	2472.6	9.1	Ba,	2472.8	9.9	M.			
163266	R Draconis	2436.2	7.5	Ch,	2436.6	7.0	Pt,	2436.8	7.1	M,	2451.6	7.5	Y,
		2463.6	7.8	Pi,	2472.6	8.3	Ba,	2472.8	8.9	M,	2484.6	9.4	O,
		2485.6	9.6	Jk,	2485.7	9.3	Po,	2493.8	9.7	Pt.			
164055	S Draconis	2472.8	9.0	M.									
164319	RR Ophiuchi	2494.8<11.5	M.										
164715	S Herculis	2464.6	8.3	Jk,	2472.8	8.3	M,	2483.6	8.1	Pi,			
		2484.6	8.3	O,	2487.7	8.0	Pt.						
165202	SS Ophiuchi	2461.7<12.4	M,	2472.8	10.4	M.							
165631	RV Herculis	2461.6<12.2	M,	2483.6<13.4	Pi.								
170215	R Ophiuchi	2407.4	11.0	Ch,	2432.3	10.8	Ch,	2437.8	10.8	Pt,			
		2463.7	9.2	Mu,	2482.7	8.9	Mu,	2482.7	8.9	Pt,	2489.7	8.4	M.
170627	RT Herculis	2461.6	8.8	M,	2476.8	9.5	M,	2485.6	9.5	O,	2493.7	9.5	Pt.
171401	Z Ophiuchi	2429.6	9.1	Ja,	2436.7	9.1	Pt,	2466.9	9.0	V,			
		2481.7	10.0	V,	2482.7	9.9	Pt,	2488.8	10.3	M.			
171723	RS Herculis	2430.5	12.4	Ja,	2483.6	9.0	Pi,	2487.7	8.7	Pt,	2488.8	8.4	M.
172809	RU Ophiuchi	2429.6	9.1	Ja,	2461.7	10.7	M,	2466.8	11.1	M,	2488.8	12.0	Pt.
173557	TY Draconis	2455.4	8.9	Pe.									
175111	RT Ophiuchi	2488.8<11.6	M.										
175458a	T Draconis	2462.6	10.0	Y,	2485.6	9.7	Jk,	2486.6	10.3	Pi.			
175458b	UY Draconis	2485.6	11.4	Jk.									
175519	RY Herculis	2425.3	8.5	Ch,	2435.2	8.6	Ch.	2461.6	10.8	M,			
		2469.8	11.1	M,	2483.6	12.1	Pi,	2493.7	12.6	Pt.			
175654	V Draconis	2487.8	9.8	M.									
180531	T Herculis	2383.5	7.6	Ch,	2398.3	8.9	Ch,	2422.6	10.2	L,			
		2425.2	11.0	Ch,	2430.4	9.8	Pe,	2434.6	10.6	L,			
		2436.7	10.9	Pt,	2454.4	11.2	L,	2461.6<11.6	M,				
		2465.4	11.7	L,	2466.8	11.8	M,	2466.8	11.3	V,			
		2482.7	10.7	Pt,	2483.6	10.5	Pi,	2484.7	10.2	O.			
180565	W Draconis	2449.8	9.9	M,	2461.6	10.4	M,	2464.6	10.2	Jk,			
		2491.8	11.8	M.									
180666	X Draconis	2461.6	11.3	M,	2491.8	12.1	M.						
180911	Nova Ophiu. 4	2430.5	10.8	L,	2436.7	10.4	Pt,	2437.8	10.5	Pt,			
		2439.8	10.2	Pt,	2440.6	10.4	L,	2459.7	10.5	Pt,			
		2460.5	10.4	L_2,	2466.8	10.6	V,	2468.8	10.5	Pt_2,			
		2483.6<11.7	Pi,	2483.6	10.7	Pt_2,	2491.2	10.6	Pt_4.				
181103	RY Ophiuchi	2461.7	9.0	M,	2471.8	8.0	M.						
181136	W Lyrae	2429.5	9.3	Ja,	2430.4	9.2	L,	2436.7	9.0	Pt,	2446.7	8.0	Pi,
		2457.3	7.7	L,	2461.7	7.5	M,	2462.6	7.6	Y,	2463.7	8.0	Mu,
		2475.8	7.4	M,	2482.7	8.1	Mu,	2482.7	8.0	Pt,	2486.6	8.1	Pi,
		2486.6	7.8	Y.									
182224	SV Herculis	2430.4<12.5	L,	2468.4	11.2	L.							
182306	T Serpentis	2429.6	9.9	Ja,	2436.8	10.1	M,	2437.8	10.1	Pt,			
		2470.8	11.6	Pt,	2494.8	12.5	M.						
183149	SV Draconis	2451.6	11.0	Y,	2486.6	9.8	Y,	2489.7	9.4	M.			
183225	RZ Herculis	2451.6	10.0	Y,	2488.7	10.5	Pt,	2490.6	11.5	Y.			
183308	X Ophiuchi	2434.6	7.1	L,	2465.6	6.4	L,	2474.9	6.9	Ml,	2487.8	6.5	M.
184134	RY Lyrae	2489.7<11.2	M.										

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
184205	R Scuti	2407.4	5.4	Ch,	2412.7	5.2	L,	2422.6	5.1	L,	2429.6	5.4	Ja,
		2430.5	5.2	L,	2432.4	5.0	Ch,	2436.8	5.0	M,	2436.8	5.5	Pt,
		2437.8	5.4	Pt,	2439.8	5.7	Pt,	2440.6	5.2	L,	2443.6	5.4	L,
		2445.5	5.5	Ja,	2453.7	5.6	Pt,	2456.6	6.0	L,	2458.6	5.9	L,
		2459.5	5.9	L,	2459.7	5.7	Pt,	2459.8	6.1	Mu,	2466.8	5.7	Pt,
		2467.8	5.7	Mu,	2468.4	5.4	L,	2470.8	5.6	Pt,	2474.8	5.2	M,
		2480.7	5.8	Mu,	2482.6	5.8	Bh,	2482.7	5.4	Pt,	2482.7	5.6	Mu,
		2483.6	5.5	Bh,	2484.6	4.9	Pt,	2484.7	5.8	Mu,	2485.7	5.8	Bh,
		2487.7	5.6	Pt,	2487.8	5.3	M,	2488.7	5.7	Pt,	2488.7	4.8	Su,
		2488.8	5.8	Mu,	2490.6	6.0	Hn,	2491.8	5.8	Pt,	2493.6	5.8	Pt,
		2494.6	5.8	Pt,	2494.7	5.5	Su,	2495.7	5.3	Su.			
184243	RW Lyrae	2489.7	<12.3	M.									
184300	Nova Aquil. 3	2407.4	8.1	Ch,	2429.6	8.3	Ja,	2432.3	8.1	Ch,	2436.8	8.4	Pt,
		2436.8	8.3	M,	2437.8	8.3	Pt,	2439.8	8.7	Pt,	2444.6	8.5	L,
		2453.7	8.4	Pt,	2458.6	8.5	L,	2459.7	8.7	Pt,	2466.8	8.9	V,
		2468.8	8.5	Pt_2,	2469.5	8.4	Ro_2,	2471.6	8.6	L,	2474.8	8.6	M,
		2481.5	8.6	Ro,	2483.6	8.6	Pt_2,	2486.5	8.6	Ro,	2487.8	8.5	M,
		2490.6	7.9	Cl,	2491.3	8.6	Pt_5.						
184748	TU Draconis	2455.4	<13.0	Pe.									
185032	RX Lyrae	2429.5	13.1	Ja,	2453.7	12.1	Pt,	2466.8	12.1	Pt.			
185634	Z Lyrae	2461.7	11.4	M,	2493.8	13.0	M.						
185905	V Aquilae	2474.9	7.1	Ml.									
190108	R Aquilae	2460.8	11.4	M,	2474.8	11.4	M,	2478.7	11.5	Ml,			
		2484.7	11.6	Pt.									
190529	V Lyrae	2462.6	10.7	Y,	2482.7	11.3	Pt,	2490.6	11.5	Y,	2494.8	11.8	M.
190925	S Lyrae	2489.7	<11.2	M.									
190933a	RS Lyrae	2461.7	10.7	M,	2494.8	11.4	M.						
190941	RU Lyrae	2461.7	<12.3	M.									
190967	U Draconis	2439.8	9.1	M,	2494.8	11.3	M.						
191007	W Aquilae	2461.6	8.8	M.									
191019	R Sagittarii	2437.8	7.3	Pt,	2466.8	8.2	Pt,	2494.8	9.8	M.			
191033	RY Sagittarii	2422.6	5.9	L,	2443.6	7.4	L,	2455.6	5.9	L,	2459.6	6.5	L,
		2466.6	6.7	L,	2470.6	6.6	L,	2493.8	6.3	Pt.			
191319	S Sagittarii	2494.8	11.5	M.									
191350	TZ Cygni	2451.6	11.0	Y,	2490.6	11.0	Y.						
191637	U Lyrae	2436.7	10.1	Pt,	2449.8	10.3	M,	2470.8	10.0	Pt,			
		2489.7	10.5	M,	2490.7	10.4	Pi.						
192928	TY Cygni	2436.8	<12.9	M,	2474.8	12.8	M.						
193311	RT Aquilae	2474.8	12.8	M.									
193449	R Cygni	2407.4	9.6	Ch,	2432.4	10.6	Ch,	2436.7	10.0	Pt,			
		2439.8	10.3	M,	2455.9	11.5	Pe_2,	2463.7	11.5	Ba,			
		2466.8	10.4	M,	2466.9	11.2	V,	2478.7	11.3	Ml,			
		2484.7	11.5	Pt,	2490.7	11.8	Pi.						
193509	RV Aquilae	2485.6	10.3	O,	2493.7	9.9	Pt.						
194048	RT Cygni	2407.4	9.7	Ch,	2432.4	10.9	Ch,	2437.8	11.7	Pt.			
		2439.8	11.5	M,	2446.7	11.2	Pi,	2463.7	9.0	Ba,			
		2466.8	9.1	M,	2484.6	8.9	O,	2484.7	8.3	Pt,			
		2490.7	8.0	Pi.									
194348	TU Cygni	2437.8	12.0	Pt,	2439.8	11.7	M,	2463.7	<12.1	Ba,			
		2466.8	13.0	M,	2490.7	<12.1	Pi.						
194604	X Aquilae	2449.8	10.4	M,	2487.8	12.2	M.						

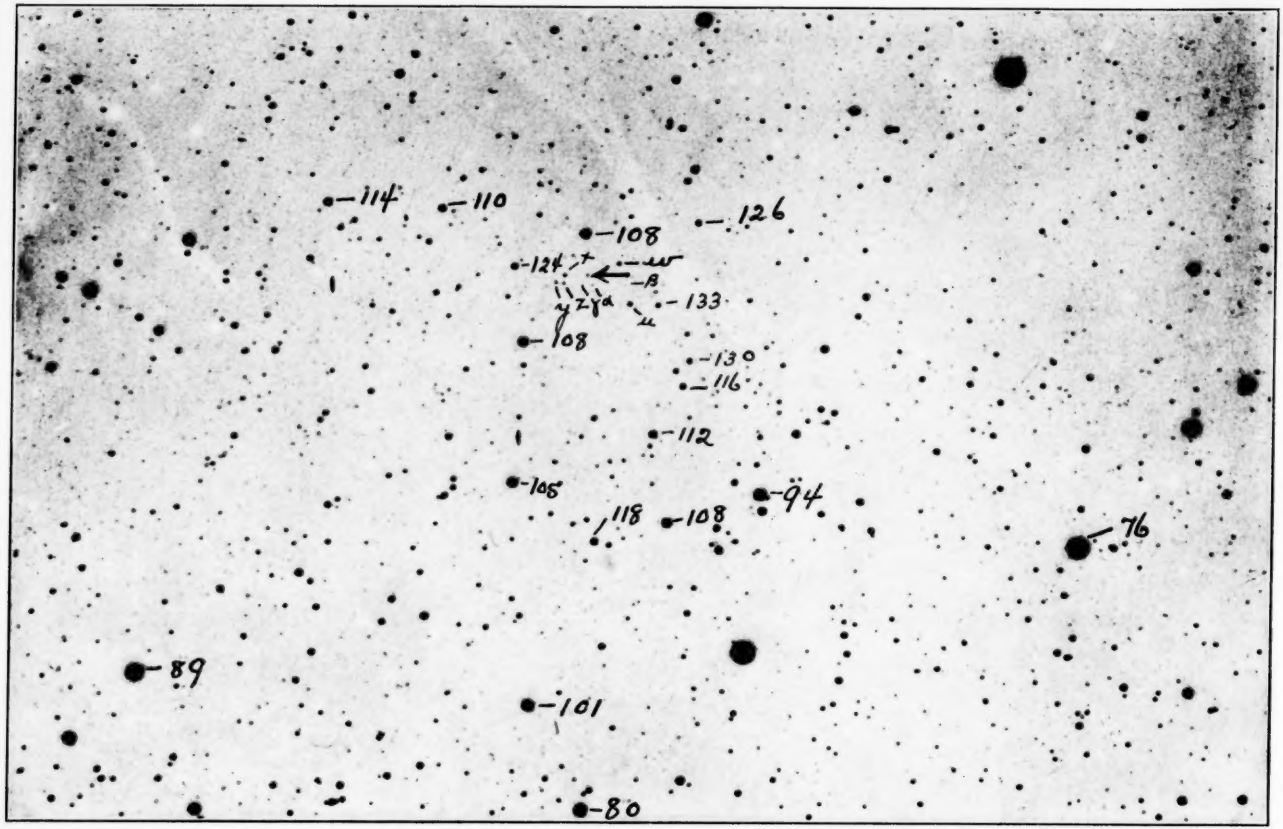
VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
194632	χ Cygni	2429.5	10.4	Ja,	2432.4	10.8	Ch,	2436.8	9.8	M,			
		2455.9	9.6	Pe_2,	2463.7	9.0	Ba,	2466.9	8.6	V,			
		2470.8	8.4	Pt,	2471.8	8.3	M,	2474.9	8.5	Ml,			
		2484.6	7.0	O,	2487.8	6.3	M,	2490.6	6.0	Pi.			
195116	S Sagittae	2467.8	6.3	Mu,	2474.7	6.0	Wg,	2483.7	6.2	Mu_2			
		2488.8	5.4	Mu.									
195849	Z Cygni	2436.8	9.2	Pt,	2439.8	8.7	M,	2446.7	8.7	Pi,	2456.4	8.6	Pe,
		2463.7	9.2	Mu,	2466.8	9.0	M,	2466.8	9.4	V,	2466.8	9.6	Pt,
		2482.7	10.1	Mu,	2490.7	10.8	Pi.						
200212	SY Aquilae	2422.6	9.8	L,	2455.6	10.9	L,	2459.8	11.8	M,	2466.6	11.3	L,
		2474.8	11.6	M,	2489.8	11.8	M,	2490.6	11.8	Pi,	2491.8	11.8	Pt.
200357	S Cygni	2446.7<11.4		Pi,	2478.7	8.9	Ml,	2487.8	9.5	M,	2493.7	9.6	Pt.
200647	SV Cygni	2449.8	8.8	M,	2463.7	9.0	Mu.						
200715a	S Aquilae	2437.8	9.4	Pt,	2459.8	9.6	M,	2466.8	9.6	Pt,			
		2473.8	8.5	M,	2490.6	10.3	Pi.						
200715b	RW Aquilae	2459.8	8.8	M,	2473.8	8.4	M,	2490.6	9.3	Pi.			
200747	RX Cygni	2463.7	7.8	Mu.									
200812	RU Aquilae	2459.8	12.1	M.									
200822	W Capricor.	2439.8	10.8	Pt.									
200916	R Sagittae	2459.8	9.0	M,	2473.8	9.1	M.						
200938	RS Cygni	2430.5	8.9	L,	2432.4	8.6	Ch,	2436.8	8.8	M,	2437.8	8.7	Pt,
		2449.8	8.4	M,	2454.4	8.1	L,	2456.4	8.9	Pe,	2460.5	7.7	L,
		2470.8	8.4	Pt,	2471.8	8.5	M.						
201008	R Delphini	2439.8	10.5	Pt,	2440.6	10.2	L,	2459.6	11.4	L,	2459.8	12.0	M,
		2488.8	12.4	Pt.									
201121	RT Capricorn.	2443.6	7.1	L,	2459.6	7.0	L.						
201130	SX Cygni	2460.8	12.0	M,	2490.6<12.6		Y.						
201647	U Cygni	2436.8	10.3	M,	2436.8	9.8	Pt,	2455.9	11.8	Pe_2,			
		2463.7<11.0		Mu,	2466.8	10.3	M,	2474.9	10.7	Ml,			
		2488.8	11.3	Pt,	2490.7	10.8	Pi.						
202639	RW Cygni	2436.8	9.2	M,	2449.8	8.9	M,	2471.8	9.0	M.			
202817	Z Delphini	2490.6<11.7		Pi,	2491.8	11.9	Pt.						
202946	SZ Cygni	2436.8	9.8	M,	2449.8	9.9	M,	2471.8	9.4	M.			
202954	ST Cygni	2439.8	11.4	M,	2459.8	11.1	M,	2459.8	11.0	Pt,			
		2462.6	11.0	Y,	2469.8	10.8	M,	2470.8	11.0	Pt,			
		2485.6	10.2	Jk,	2490.7	10.1	Pi.						
203226	V Vulpeculae	2436.8	8.7	Pt,	2460.8	9.6	M,	2466.8	9.6	Pt.			
203611	Y Delphini	2429.6<12.4		Ja,	2493.8<12.1		M.						
203816	S Delphini	2459.8	10.5	M,	2466.9<11.0		V,	2487.8	10.1	M.			
203847	V. Cygni	2439.4<10.0		Ch,	2461.7	10.5	M,	2469.8	10.3	M,	2474.9	9.5	Ml.
203905	Y Aquarii	2494.8	9.5	M.									
204016	T Delphini	2437.8	10.8	Pt,	2459.8	11.8	M,	2470.8	12.4	Pt,			
		2487.8<12.6		M.									
204104	W Aquarii	2440.6	10.0	L,	2460.6	11.8	L.						
204405	T Aquarii	2407.5	9.8	Ch,	2460.8<11.5		M,	2494.8	12.4	M.			
204846	RZ Cygni	2439.8	10.6	M,	2490.7<11.6		Pi.						
205017	X Delphini	2491.8	11.2	Pt.									
205923	R Vulpeculae	2439.8	11.1	M,	2459.8	9.2	Pt,	2466.8	9.1	Pt,	2491.8	8.0	M.
210129	TW Cygni	2449.8	11.6	M,	2476.8	11.0	M,	2490.6<12.		Y,			
210382	X Cephei	2439.8	9.7	M,	2460.8	10.1	M,	2476.8	10.8	M.			
210504	RS Aquarii	2458.6<11.9		L,	2460.8<11.5		M.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1920—Continued.

Number	Name	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
210868	T Cephei	2422.6	6.2	L,	2433.3	6.4	L,	2436.8	6.7	Pt,	2442.3	7.4	Ch,
		2451.4	6.7	L,	2460.5	6.9	L,	2470.6	7.1	L,	2471.8	7.8	M,
		2474.9	8.1	Ml,	2482.7	8.3	Pt,	2485.6	8.1	O.			
210903	RR Aquarii	2484.8	<12.1	M.									
211614	X Pegasi	2494.8	12.3	M.									
213244	W Cygni	2422.6	6.0	L,	2430.5	6.1	L,	2434.6	6.2	L,	2451.4	6.1	L,
		2458.4	5.9	L,	2465.4	5.9	L,	2471.6	5.7	L.			
213678	S Cephei	2439.8	8.8	M,	2471.8	9.7	M,	2474.9	8.5	Ml.			
213753	RU Cygni	2449.8	8.8	M,	2467.8	8.1	M.						
213843	SS Cygni	2407.4	8.3	Ch,	2413.4	10.2	Ch,	2422.6	11.7	L,			
		2429.5	11.6	Ja,	2430.5	12.0	L,	2432.4	<11.5	Ch,			
		2433.6	11.5	L,	2434.6	11.7	L,	2436.8	11.6	M,			
		2436.8	11.7	Pt,	2437.8	11.9	Pt,	2439.8	11.9	Pt,			
		2439.8	11.5	M,	2440.6	11.9	L,	2443.6	11.6	L,			
		2444.6	11.5	L,	2446.7	<10.9	Pi,	2449.8	11.5	M,			
		2451.4	11.8	L,	2453.7	11.9	Pt,	2453.7	11.7	Pi,			
		2453.8	11.8	Ba,	2454.4	11.8	L,	2456.6	11.6	L,			
		2457.4	<11.0	L,	2458.5	11.5	L,	2459.5	10.1	L,			
		2459.7	9.9	Pt,	2459.8	9.3	M,	2460.5	8.4	L,	2460.8	8.4	M,
		2461.8	8.2	M,	2462.6	8.5	Pi,	2463.6	8.6	Pi,	2463.7	8.8	Ba,
		2464.4	8.5	L,	2465.4	8.9	L,	2466.5	9.8	L,	2466.8	10.2	M,
		2466.8	9.9	Pt,	2466.9	10.1	V,	2467.8	10.3	M,	2468.4	10.1	L,
		2469.8	10.6	M,	2470.5	11.1	L,	2470.8	11.0	M,	2470.8	11.0	Pt,
		2471.6	11.4	L,	2471.7	11.5	Ba,	2471.8	11.3	M,	2472.6	11.5	Ba,
		2472.8	11.5	M,	2473.8	11.5	M,	2474.8	11.6	M,	2482.7	11.8	Pt,
		2484.6	11.8	Pt,	2484.6	<10.9	O,	2485.6	<10.9	O,			
		2485.6	11.5	Jk,	2485.8	11.6	M,	2486.6	<11.0	Pi,			
		2487.7	11.7	Pt,	2487.8	11.6	M,	2488.7	11.8	Pt,			
		2489.8	11.5	M,	2490.6	11.0	Cl,	2490.7	12.0	Pi,			
		2491.8	11.2	M,	2491.8	11.7	Pt,	2493.6	10.1	Pt,			
		2493.8	9.5	M,	2494.6	8.3	Pt,	2494.8	8.6	M,	2495.6	8.5	K,
		2495.8	8.3	M.									
213937	RV Cygni	2449.8	7.8	M,	2471.8	8.3	M.						
214024	RR Pegasi	2494.8	<12.0	M.									
215605	Y Pegasi	2493.8	11.8	M.									
220412	T Pegasi	2459.6	10.8	M.									
222439	S Lacertae	2440.6	9.0	L,	2458.6	8.2	L,	2495.8	9.5	M.			
223841	R Lacertae	2459.6	<12.3	L,	2474.9	<11.5	Ml.						
225914	RW Pegasi	2494.8	12.6	M.									
230110	R Pegasi	2460.8	10.1	M,	2491.8	11.4	M.						
230759	V Cassiop.	2436.8	9.4	Pt,	2472.8	11.4	M,	2488.8	11.4	Pt,	2493.8	11.8	M,
231425	W Pegasi	2440.6	9.3	L,	2458.6	9.7	L,	2474.8	10.5	M.			
233335	ST Androm.	2439.8	9.0	Pt,	2460.8	9.4	M,	2471.8	9.7	M,	2488.8	9.7	Pt.
233815	R Aquarii	2474.9	10.2	Ml.									
235350	R Cassiop.	2491.8	10.0	M.									
235525	Z Pegasi	2491.8	8.6	Pt.									
235939	SV Androm.	2493.8	11.4	M.									

	April-May	May-June	Total
Observations	608	756	1364
Stars			245
Observers	19	26	31



Photographed Field of the Variable Star SS Aurigæ with Stars of the Magnitude Scale Marked. The Variable is at the Point of the Arrow.
R.A. 1900.0 6^h $05^m.8$; Dec. 1900.0 + 47° 46′.

After a most pleasant year spent at Harvard University, and at the Observatory, the Recording Secretary has returned to his home, 428 Lake St., Madison, Wisconsin. All observers are requested hereafter to prepare their reports in duplicate and to send one copy, for use in predictions and permanent file, to the Harvard College Observatory, Cambridge 38, Mass., and the other copy, for publication, to the Recording Secretary, at the above address. The reports should be mailed, as before, so as to arrive before the 20th of the month. It will be noticed that a change has been introduced in the form in which the observations are printed. This in no way detracts from the value of the record, in fact, in some respects it is believed it will make the reports more convenient, e. g., in looking up desired stars. The ease of printing is materially increased by the change, which it is hoped will meet with approval.

The following members contributed to this report: Messrs. Berger, Bancroft, Bouton, Brown, Bunch, Chandra, Clement, Eaton, Gartlein, Godfrey, Henckel, Janczewski, Jordan, Kimball, Lacchini, McAteer, Merrill, Mundt, Olcott, Peltier, de Perrot, Pickering, Potter, Rhorer, Suter, Vrooman, Woglom, Yalden, and Yamamoto, and the Misses Jenkins and Young.

HOWARD O. EATON,
Recording Secretary.

The Field of SS Aurigae.—The accompanying Plate has been prepared as the Frontispiece to Publication No. 8 of Goodsell Observatory "Observations of Variable Stars in 1916-19," which is just being issued. The Plate is a reproduction of a portion of a photograph taken at Harvard College Observatory with the 16-inch Metcalf telescope. The Variable SS Aurigæ at minimum goes below 15th magnitude and is probably fainter than any of the stars shown on the photograph. On the plate a faint image of it is shown at the point of the arrow. The members of the American Association of Variable Star Observers will be interested in the scale of magnitudes indicated by the figures and letters written on the photograph. The stars marked α, β, γ are probably below magnitude 15.0.

Nova Ophiuchi No. 4.—The following observations of Nova Ophiuchi, No. 4, $18^h\ 10^m\ 20^s.45$, $+\ 11°\ 35'\ 15''.8$ (1910.0), by Professor E. E. Barnard, have been communicated by Professor Edwin B. Frost, Director of the Yerkes Observatory.

"For some time, this star has presented a remarkable appearance in the 40-inch telescope. It resembles a very small bright stellar nebula, the star image itself (which is stellar) being almost lost in the dense glow about it. On May 13, and subsequent dates, this glow or nebulosity was very conspicuous; the focus did not differ from that of an ordinary star. On June 10, the focus had increased 4 mm. The star was then of magnitude about 11½, and was imbedded in a very small dense nebulosity which measured 2".3 in diameter. In appearance it strongly resembles some of the Wolf-Rayet stars."

S. I. BAILEY.

Harvard College Observatory, Bulletin 723.
Cambridge, Mass., U. S. A., June 16, 1920.

Photographed Field of the Variable Star SS Aurigæ with Stars of the Magnitude Scale Marked. The Variable is at the Point of the Arrow.
R.A. 1900.0 $6^h\ 05^m.8$; Dec. 1900.0 $+\ 47°\ 46'$.

COMET AND ASTEROID NOTES.

Ephemeris of Tempel's Second Periodic Comet.—Mr. F. E. Seagrave sends us the following ephemeris, computed from elements published in 1910. Of course there is considerable uncertainty in computations based upon elements ten years old, but if the observation reported from Japan on May 25 is correct the comet is not far from the ephemeris place.

No further observations have so far come to hand, so that there may be possibly some question as to the comet's visibility. Unfortunately for northern observers the course of the comet goes rather far south during August.

EPHEMERIS OF TEMPEL'S SECOND COMET.

	α			δ			log r	log Δ
1920	h	m	s	°	′	″		
Aug. 2	0	29	28	—14	5	56	0.12954	9.66536
6	0	37	21	—15	22	47	0.13246	9.66602
10	0	44	25	—16	39	24	0.13586	9.66860
14	0	50	4	—17	58	32	0.13954	9.67168
18	0	54	39	—19	15	32	0.14374	9.67684
22	0	58	29	—20	29	11	0.14802	9.68285
26	1	1	10	—21	39	9	0.15270	9.69049
30	1	2	50	—22	44	8	0.15768	9.69950

COMMUNICATIONS

Occultations of Jupiter's Satellites, One by Another.—Several times this spring during the months of March, April and May, I have observed one of Jupiter's four moons pass behind or in front of another, causing the two to appear in the telescope as one moon, or making an eclipse. Supposing it to be a common occurrence, I made no special note of the observation. But on looking through half a dozen works on Astronomy, as well as the *American Ephemeris,* I could find no mention of anything of that kind taking place, so I determined to look more closely and make inquiries. On the evening of May 29, time 9^h 15^m P. M., observed Satellite 3 emerge from shadow,—seeing good. May 29, time 11^h P. M., observed Satellite 1 pass behind 4,—these two moons now appeared as one for about forty minutes before I could separate them using powers of 56 and 76 with 4-inch objective. What I am anxious to know is, do the earth and Jupiter have to be specially situated in their orbits for this phenomenon to take place? And why is no mention made of it by astronomers?

FRED S. CARRINGTON.

The Next Discoveries in Astronomy.—It is not for any of us to say just what will be the next great discoveries in Astronomy, as they *may* be in a direction and come from a source and in a manner that we little expect. I might suggest some discoveries that are awaited by us all:

1. Whither is our solar system drifting?

2. Does this drifting motion of the solar system have any effect on the planets?

3. We want another Herschel to make further discoveries in regard to the Milky Way.

4. Does our Sun belong to any constellation?

5. If our Sun does not belong to any constellation, then is it a solitary star, if there be such?

6. May it not be a fact that in outer space there may be a vast number of extinct suns, invisible to us, but yet having gravitational hold on all other neighboring stars?

7. May not some of the stellar attractions, disturbances and influences that have been noted, come from extinct suns and stars?

8. What, if any, electric forces pass between the planets?

9. Can a white hot star, which is probably entirely gaseous, produce electricity?

10. Most all our explanations of vast and complicated planetary and stellar motions are based on the law of gravitation, which may be expressed in forty words; will some later Newton arise and discover some governing stellar laws?

To be sure, there are many other questions that have arisen in the minds of different people, some of which, may be more important than those I mention, but these questions have perhaps arisen in the minds of all of us.

So. Austin, Texas. GEO. B. HUFFORD.

GENERAL NOTES.

The next number of POPULAR ASTRONOMY will be issued about October 1.

Dr. Frank Schlesinger, director of the Yale Observatory, received the degree of Doctor of Science from the University of Pittsburgh, at its commencement on June 9.

Dr. A. Berberich, the noted German astronomer, who has done much valuable work in the computation of comet and asteroid orbits, died on April 27, 1920.

Dr. Keivin Burns has been appointed to a position at the Allegheny Observatory and has begun his work there.

Mr. E. A. Milne, Fellow of Trinity College, Cambridge, England, has been appointed Assistant Director of the Solar Physics Observatory, Cambridge University.

Changes on Mars.—A letter from Professor W. H. Pickering, of Mandeville, Jamaica, contains the following statements concerning his observations of Mars, announced in Bulletin 720.

"The northern polar cap has varied but little in size since the first of last March, when it reached its smallest dimensions, some three weeks after the Martian summer solstice. The latitude of its southern limit has ranged from

82° to 84°, and its diameter has averaged 500 miles (800 kilometers). The southern polar cap has been visible as a narrow band for several weeks."

"On the evening of June 1 nothing unusual was noted in the Utopia Panchaia region, lying north of the conspicuous canals Casius and Gyndes, but the following night, August 27 on the Martian calendar, the whole region, covering some 800,000 square miles, was of dazzling brilliancy. It extended from latitude +40° to the polar cap, but was separated from the latter by a narrow dark band less than 100 miles in width."

"It may be noted here that the Martian greens have reappeared in Libya, having been absent since early in 1916."

S. I. BAILEY.

Harvard College Observatory, Bulletin 723.
Cambridge, Mass., U. S. A., June 16, 1920.

Facts About Einstein.—Conflicting statements about the nationality of Prof. Einstein, of relativity fame, have appeared in the daily press, and Einstein himself vouch-safed some facetious remarks on the subject in the London *Times* when popular interest in his theory was at its height. From a more recent interview with Einstein, published in the London *Daily Chronicle*, it appears that he is a German by birth, but went to Switzerland at an early age and was naturalized in that country. For some years he was professor of physics at the Polytechnikum, in Zurich, and also, for a short time, at the University of Prague. Shortly before the late war began he was called to the University of Berlin, where he still is, being at the same time director of the Kaiser Wilhelm Institute for Physical Research. He is now little more than forty years of age, and he conceived the outlines of his theory of relativity at the early age of eighteen. He was only twenty-seven when he presented it to the world.—(*Scientific American*, May 29, 1920.)

A Remarkable Wind Velocity.—Mr. W. R. Gregg reports in the *Monthly Weather Review* that during a pilot-balloon flight over Lansing, Mich., on the morning of December 17, 1919, a wind of 83 meters per second (186 miles an hour) was observed at an altitude of 7,200 meters (about 4½ miles). So far as known, this is the highest wind speed ever observed in the atmosphere of altitudes less than 10 kilometers. Exactly the same velocity was recorded by an anemometer on Mount Washington in 1878, but anemometer readings at high velocities are always much in excess of the true speed of the wind. At great altitudes much higher velocities undoubtedly occur. Cirrus clouds have been known to move at speeds of 200 miles an hour and upwards, and the drift of meteor trails seem to indicate that the highest winds of all occur far above the cloud level, though the interpretation of such observations is a matter of controversy.—(*Scientific American*, May 22, 1920.)

The Total Solar Eclipse of September 21, 1922.—The following statement concerning the total solar eclipse of September 21, 1922, was given by Mr. A. R. Hinks at the April, 1920, meeting of the Royal Astronomical Society (London). The eclipse will be more suitable for testing Einstein's theory than will be the eclipse of 1923. At Christmas Island the eclipse will occur when the sun is high, and totality will last about 3½ minutes.

"The eclipse begins on the east coast of Africa and crosses the Indian Ocean to Australia. In the path of the track lie Maldive Islands and Christmas Island. The eclipse will take place in the Maldive Islands at 8 o'clock in the morning, at Christmas Island just before mid-day, and at the first really accessible point in Australia at 4 o'clock in the afternoon. These are the three possible alternatives, and I shall consider them in turn.

"The Maldives form an interesting archipelago in the Indian Ocean S.W. of India. They are a long series of ring atolls enclosing lagoons with many islands. These islands are civilized and ruled by a sultan, who pays tribute to Ceylon. There is still much evidence of a former Portuguese occupation in the forts and buildings. By the descriptions of these islands in the 'West Coast of India Pilot' they are singularly suited for the convenience of eclipse expeditions. The people are skilled navigators, who make and repair astrolabes and quadrants, and translate books on navigation and astronomical tables. They can build palm houses, such as would shelter instruments, in 24 hours, so Prof. Stanley Gardiner assures me. The central line crosses the atolls of South Nilandu Malaku. The observing camp should be on an inner island as there is a very heavy surf which shakes the outer reef. It will be well to choose an uninhabited island. for the inhabited ones are reputed very unhealthy, doubtless on account of bad sanitary conditions. A gunboat would be required for an expedition to the Maldives, and men interested in other sciences, such as Zoology, would probably like to join. The islands are covered with coco-nut palms, which can be cut into rollers for moving heavy loads. A strong party may be required to make a clearance for the camp. I have written to Ceylon for information about the meteorological conditions. Prof. Gardiner informs me that the monsoon is over early in September in this latitude, and that there is a seven to one chance in favor of clear weather accompanied by a rather heavy wind.

"Christmas Island is where Sir John Murray made a fortune by his scientific knowledge; while on the 'Challenger' expedition he discovered phosphates on this island, and founded the company which now works them. All along the coast there are steep undercut cliffs, so that the greater part of the coast is inaccessible. The island has risen in geologically recent times, and coral reefs are to be found 30 to 40 feet out of the water. For the same reason there are cliffs inland also. On account of the phosphates there is now a considerable settlement at Flying Fish Cove, where there are piers and cranes to handle 5 tons. The population consists of 15 Europeans and a thousand Malays and Chinese. A standard-gauge railway runs to the southern end of the island, which is where observers will want to go; the duration of totality will be about 3½ minutes there. The weather conditions are very favorable, as is shown by the records of the company's meteorological station, which reports to the Scottish Meteorological Society. The rainfall in September is very slight. The amount of cloud is 3 in a scale of 10, and this decreases after the morning, although the humidity increases towards evening. Mr. Martin, the Secretary of the Phosphate Company, is prepared to welcome an eclipse party sent by the Astronomer Royal. Both skilled and unskilled labor are obtainable, and a settlement will be built in the south before 1922. A good deal of clearing may be required if this has not been done by the Phosphate Company. The Island is thickly wooded, with limestone crags in the forest. Land-crabs, which may attain 2 feet across, are numerous at times and may be rather formidable. Two chronometers belonging to Admiral Wharton's party were carried off by them. Andrews has given a lurid account

of the noise made by the land-crabs as they 'approach from all directions.' The Island is reached by the Company's steamer monthly from Singapore. There are no stores in the island, and everything required will have to be brought. The only objection to this station is that it is rather far from the central line.

"The eclipse track reaches Australia at Ninety-Mile Beach, a hopeless part of the coast, and strikes into the great desert. There are no facilities for landing. 'You can approach within four miles of the shore in small boats.' The desert is inaccessible, except to camels. There are no railways within hundreds of miles, and motor cars are out of the question. The first place which is feasible is Cunnamulla, in South Queensland. This is the terminus of the railway from Brisbane, and is a comparatively large and well-found town. Totality will be about $3\frac{1}{2}^{m}$ at 4 P. M. The next station on the railway is right on the central line. Maps show a railway projected farther west, but this does not exist. I have not yet received full meteorological data. The rainfall is 18 inches a year."

The American Astronomical Society will hold its twenty-fourth annual meeting September 1 to 4, 1920, at Smith College, Northampton, and Mt. Holyoke College, South Hadley, Mass. Headquarters for the meeting will be at the Gillett House, one of the college dormitories at Northampton, and it is hoped that most of the members of the Society will be housed there, together with any ladies of their families or guests who may accompany them.

Northampton is on the Connecticut River Division of the Boston and Maine Railroad. This connects at Springfield with the New York, New Haven and Hartford trains from the south, and with the Boston and Albany trains from the east and west.

The following is the Preliminary Program, recently sent out by Secretary Joel Stebbins:

TUESDAY, AUGUST 31, 1920.

8 P. M. Meeting of the Council at the Observatory.

WEDNESDAY, SEPTEMBER 1.

10 A. M. Opening Session, Lecture room, Burton Hall.
2 P. M. Session for Papers, Lecture room, Burton Hall.
4 P. M. Tea at the Observatory.
8 P. M. Reception at the Art Gallery.

THURSDAY, SEPTEMBER 2.

8:45 A. M. Special car for Mount Holyoke College, South Hadley, starting in front of the Gillett House. Meeting of the Council en route.
10 A. M. Session for papers, Dwight Hall.
12:30 P. M. Complimentary luncheon, Mary Brigham Hall.
2 P. M. Session for papers, Dwight Hall.
4 P. M. Inspection of grounds and buildings. Tea at the Observatory.
5:30 P. M. Special car for Northampton.

FRIDAY, SEPTEMBER 3.

9 A. M. Meeting of the Council, Library of Burton Hall.
10 A. M. Session for papers, Lecture room, Burton Hall.
2 P. M. Session for papers, Lecture room, Burton Hall.
8 P. M. Conversazione, exhibits, etc., Lecture room, Burton Hall.

SATURDAY, SEPTEMBER 4.

9 A. M. Meeting of the Council, Library of Burton Hall.

10 A. M. Final session for papers. Election of officers. Lecture room, Burton Hall.

The Adolfo Stahl Lectures in Astronomy.—This volume contains the twelve Adolfo Stahl lectures which were delivered in San Francisco in the seasons 1916-17 and 1917-18 under the auspices of the Astronomical Society of the Pacific by members of the staffs of the Lick Observatory, the Mount Wilson Solar Observatory, and the Students Observatory at Berkeley. They cover a wide range of topics, the endeavor being to present in non-technical language, but without sensationalism, some of the more recent results of studies of the Sun, the Moon, the Comets, the Solar System in general, the Stars and the Nebulae. One lecture, also, treats of the methods of astronomical discovery; another, of recent progress in the study of motions in the solar system; still another, of the important epochs in the development of astronomy; and the volume concludes with a description of the great 100-inch Reflector on Mount Wilson, the most powerful telescope in the world.

The volume is well illustrated. There are fifty-four full-page plates and twenty-four figures in the text. Although the illustrations were selected primarily with reference to the text, they include some which are of historic interest and others which present some of the most recent developments of astronomy. For example, we have Keeler's beautiful drawing of Saturn made on January 7, 1888, the night on which the first successful observations were secured with the 36-inch refractor of the Lick Observatory, and the recent photographs of Jupiter, taken by Slipher at the Lowell Observatory, which are the finest ever made. Some of the stellar and nebular photographs, like the excellent one of the Pleiades by Dr. Isaac Roberts, in 1888, represent pioneer work in this field; others, like Barnard's photograph of the Milky Way in Ophiuchus and the photograph of the Great Nebula in Andromeda showing the location of the Novae recently discovered in it at Mount Wilson, are typical of the best work with modern telescopes. On one page we find a photograph of the first reflecting telescope, the historic one-inch invented by Sir Isaac Newton; on other pages, views of the 72-inch reflector at Victoria and the 100-inch reflector at Mount Wilson.

It is, of course, impossible to cover the entire field of astronomical research in a series of twelve lectures; but the topics discussed are representative of modern astronomical work, and the book will introduce the reader to the point of view from which the astronomer of today regards the problems presented to him.

Orders should be sent to Mr. D. S. Richardson, 128 Lick Building, 35 Montgomery Street, San Francisco, Cal.

Mr. Stahl has generously provided that the proceeds of the sale of the volume shall go to the Society to form a special fund.

When February has no Full Moon.—Mr. S. H. Gaythorpe has computed, with the aid of the syzygy tables in De Morgan's "Book of Almanacs," the number of times in the 19th, 20th, 21st, 22nd, 23rd, and 24th centuries in which the moon does not become full in the month of February. In the 19th century this occurred in 1809, 1847, 1866, and 1885. In the 20th, only in 1915 and 1961. In the 21st, in 2018, 2037, 2067, and 2094. In the following three centuries there

will be ten Februaries without any full moons. He says: "By a singular coincidence this happens to be of the same degree of frequency as the occurrence of five Sundays in February, though the two events are, of course, quite unrelated, the latter happening regularly thirteen times in four centuries." *(The Journal of the British Astronomical Association, April, 1920.)*

Nova Aquilae. — A telegram received here from Professor W. W. Campbell, Director of the Lick Observatory, states Moore and Aitken find that Nova Aquilae has a diameter of three and eight tenths seconds. The linear extension is apparently proportional to the time.

Harvard College Observatory, Bulletin 721.

Cambridge, Mass., U. S. A., June 9, 1920.

S. I. Bailey.

Standard Time in Argentina—Notification has been given that the Argentine Republic has adopted the meridian of Longitude 60° West from Greenwich as the standard meridian, as from midnight 1920 April 30/May 1. In consequence, time 4 hours slow on G.M.T. becomes the standard time. The change involved all clocks being advanced by $16^m\ 48^s.2$.

More "Exams."—"A centrifical force is one equal all around, when hitting a ball the force on it is the same all around till it lands."

"Scientrific force is that which changes size and shape of a body, as the spring balances the weight changes the shape and size of the spring."

"Centrifigular force is a force acting on one point such as the works of a clock or automobile."

"Cyntrivical force is a force that goes round an axis—the electric fan for instance."

"The artic circle bounds the fridget zone."

"When melted sulphur becomes very hot it becomes vicious."

"Moisture gets into the air by sublimation, evaporation and respiration."

From An Oxford Notebook in *The Observatory* June 1920.

ANTARES.

Rival of Mars with ruddy glow,
  Star of the South where the warm winds blow;
Heart of the Scorpion, blood-tinged light—
  Star of the calm midsummer night.

Glorious orb that marks the way
  Where the planets pass and the moon holds sway;
Blazing and red, though your fires grow cold—
  Dying light of a sun now old.

Beautiful star, old age has wrought
  But a kindly change in your life and lot.
Thousands of years may your glory last—
  Grand old sun of the aeons past.

William H. McEnrue.

Washington, Penn.